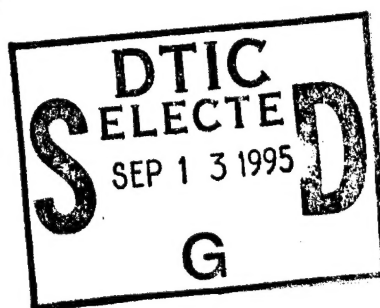


# NAVAL POSTGRADUATE SCHOOL MONTEREY, CALIFORNIA



## THESIS



**END USER INVENTORY CONSOLIDATION:  
IS IT COST EFFECTIVE?**

by

Vito Mannino and Thomas Mintzer

March 1995

Principal Advisor:

Dan Boger

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END USER INVENTORY CONSOLIDATION:  
IS IT COST EFFECTIVE?

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## **ABSTRACT**

The Naval Supply Systems Command (NAVSUP) and the Naval Air Systems Command (NAVAIR) decided to sponsor a Naval Aviation Depot (NADEP) and Fleet Industrial Supply Center (FISC) partnership to determine what material support functions, currently performed by NADEP, could be consolidated at the FISC level. A total cost analysis is conducted to evaluate the difference between pre and post-consolidation repair parts inventories. Two alternative inventory strategies are considered; end users maintaining separate inventories (for example NADEP or shipyards), and end users' inventories being consolidated at the FISC level. Principal elements include inventory holding, set up, and stock-out costs.

## TABLE OF CONTENTS

I.	INTRODUCTION . . . . .	1
	A. BACKGROUND . . . . .	1
	B. PURPOSE . . . . .	3
	C. RESEARCH QUESTIONS . . . . .	3
	D. SCOPE OF THESIS . . . . .	4
	E. LIMITATIONS AND ASSUMPTIONS . . . . .	4
	1. Assumptions . . . . .	4
	2. Limitations . . . . .	4
	F. METHODOLOGY . . . . .	5
	G. ORGANIZATION OF THE THESIS . . . . .	5
II.	BACKGROUND . . . . .	7
	A. HISTORY OF THE DEFENSE LOGISTICS . . . . .	7
	B. HISTORY OF THE FLEET INDUSTRIAL SUPPLY CENTER, SAN DIEGO . . . . .	11
	C. HISTORY OF THE NAVAL AVIATION DEPOT, NORTH ISLAND . . . . .	14
	D. THE NADEP/FISC PARTNERSHIP . . . . .	16
	E. SUMMARY . . . . .	19
III.	THE LOGISTICS CONCEPT . . . . .	21
	A. INTRODUCTION . . . . .	21
	B. LOGISTICS SYSTEM CONCEPT . . . . .	21
	1. Materials Management . . . . .	23
	2. Physical Distribution . . . . .	23
	a. Transportation . . . . .	24
	b. Inventory Management . . . . .	25
	c. Requisition Processing . . . . .	29
	d. Warehousing . . . . .	32
	C. TOTAL COST CONCEPT . . . . .	34
	1. The Total Cost Approach . . . . .	35
	2. The Total Cost Model . . . . .	35

D. SUMMARY . . . . .	37
IV. PRESENTATION OF DATA . . . . .	39
A. INTRODUCTION . . . . .	39
B. MODEL PARAMETERS . . . . .	39
C. END USER INVENTORY MANAGEMENT SCENARIO . . . . .	41
D. CONSOLIDATED INVENTORY MANAGEMENT SCENARIO . . . . .	47
E. SUMMARY . . . . .	50
V. DATA ANALYSIS . . . . .	51
A. INTRODUCTION . . . . .	51
B. SYSTEM PARAMETERS . . . . .	52
1. Economic Order Quantity (EOQ) . . . . .	52
2. Reorder Point (ROP) and Safety Stock (SS) . . . . .	54
3. Transportation Cost . . . . .	56
4. Total Distribution Cost . . . . .	57
C. DEMAND VARIANCE: AN ALTERNATE SELECTION CRITERION . . . . .	58
VI. CONCLUSION AND RECOMMENDATIONS . . . . .	63
A. CONCLUSION . . . . .	63
B. RECOMMENDATIONS . . . . .	64
LIST OF REFERENCES . . . . .	65
INITIAL DISTRIBUTION LIST . . . . .	67

## I. INTRODUCTION

### A. BACKGROUND

The dictionary defines logistics as "the procurement, distribution, maintenance, and replacement of material and personnel." [American Heritage Dictionary, 1982] In the military, we simply define logistics as everything required to provide the right item, at the right place, at the right time. For the Department of Defense (DOD), "right" is the support necessary to help deter wars, and when necessary, win wars. It includes operational logistics, acquisition logistics, the core logistics functions, and the industrial base required to provide ready and sustainable forces.

The purpose of the DOD logistics system is to create and sustain the military capability needed for national defense. This central purpose is the impetus in planning to improve the logistics system to meet future military requirements for combat capable forces.

*The DOD's overall logistics mission is to ensure quality logistics support to the total force for the full spectrum of operating scenarios.*

[Assistant Secretary of Defense (Production and Logistics), 1988]

Simply stated, this means the DOD must be ready to sustain wartime and contingency operations, while also providing economical support during peacetime.

In order to meet future readiness requirements, the Assistant Secretary of Defense (Production & Logistics) has published four major goals which capture DOD's desired logistical capability to accomplish its mission:

1. Ensure operational logistics support to meet readiness and sustainability requirements.

2. Ensure weapon system availability.
3. Improve the quality of logistics management and operations.
4. Improve industrial base responsiveness to DOD needs.

These four mandates encompass every essential logistics function common to all services and form the basis upon which all DOD support activities are conducted. The first goal applies to the part of the logistics system that directly supports the operational mission and reflects the needs of both users and providers of operational logistics support. The second goal includes acquisition and follow-on logistics support activities related to weapon system availability. The third area is the central focus of this study. It includes core logistics operations comprised of supply, maintenance, distribution, transportation and the procurement processes at all echelons of operations. The fourth goal encompasses the ever-growing need for effective interface between DOD organic and commercial industrial bases in order to accomplish the logistics mission.[Assistant Secretary of Defense (Production and Logistics), 1988]

One of the most significant influences on the Department of Defense's ability to achieve its logistics mission and goals is the availability of funding. With the end of the Cold War and the downsizing of the Department of Defense, the Department of the Navy faces the challenge of supporting the fleet with fewer resources. At the same time, it must be able to improve its logistical responsiveness to support recent increases in contingency/crisis prevention missions. To meet this challenge, the Naval Supply Systems Command (NAVSUP) and the Naval Air Systems Command (NAVAIR) decided to sponsor a Naval Aviation Depot (NADEP) and Fleet Industrial Supply

Center (FISC) partnership to evaluate what material support functions currently performed by NADEP could be consolidated at the FISC level. Specifically, we would like to determine whether or not savings are possible as a result of this partnership.

The essential thrust of the partnership concept is eliminating redundancies in logistics operations, increasing reliance on joint capabilities and capacities, and supporting geographic concentration of effort. This initiative is the FISC concept of consolidated management of distributed consumer inventories. The objective of this concept is to improve customer support and save the Navy's dwindling resources. NAVSUP and NAVAIR know that they will be the driving factor in this consolidation.

While North Island has embraced and implemented the partnership, the remaining two depots (Jacksonville and Cherry Point) are hesitant to transfer inventory functions to the local FISCs. Therefore, NAVAIR requested that pertinent data be compiled to determine the advantages and disadvantages of the partnership.

## **B. PURPOSE**

This thesis will either validate or refute current claims that this partnership will save the Department of Navy a substantial amount of money. We will present a total cost comparison between the two systems and present a recommendation to NAVSUP as to which system provides the most "bang for the buck."

## **C. RESEARCH QUESTIONS**

The thesis' primary research question is: Which inventory model realizes the lowest total distribution cost?

Subsidiary questions:

- How are the inventory models affected by variations in demand?
- Which inventory model minimizes consumer risk?
- What are some of the other factors that influence the decision to consolidate end user inventories?

#### **D. SCOPE OF THESIS**

The primary research objective is to conduct a comparative cost analysis between separate end user inventory procedures and a consolidated partnership arrangement. This research involves the study of all relevant costs and how the consolidation has affected total distribution costs.

#### **E. LIMITATIONS AND ASSUMPTIONS**

##### **1. Assumptions**

The primary objective of the partnership is to reduce overall total cost (primarily through operating efficiencies) and at the same time improve the quality of customer service. Money spent on unnecessary logistics/materials is not considered a necessary part of doing business.

Additionally, we assume fast moving consumable items will continue to be maintained at end user activities under both inventory models and are therefore excluded from this study.

##### **2. Limitations**

Application of this study is limited to the NADEP/FISC North Island partnership because of their close proximity to customer units and other support activities. Other depots and FISCs may not be able to consolidate because they are the only support activity located in a given geographic region. To recommend changes to the existing structure of

these other activities is beyond the scope of this thesis.

The trade-off analysis is limited to the study of cost elements which are incurred on a repeated basis. Specifically excluded are one-time only costs directly attributable to the consolidation such as realignments, personnel transfers and other incidental costs unique to the restructuring of various support activities and installations.

For the purposes of this study, the definition of logistics is limited to the following activities: physical distribution, materials management and inventory control.

#### **F. METHODOLOGY**

The thesis' primary methodology will be a case analysis of procedures using the NADEP/FISC North Island partnership as a model and comparing and contrasting the pre-consolidation with post-consolidation activity data. We will develop a total cost model comprised of pertinent inventory and transportation costs associated to the partnership and subsequently analyze whether or not the partnership is justifiable in terms of increased mission support capability and significant cost reductions. In conducting our research we will include a literary research of essential cost data and conduct personal interviews.

The research will be conducted using cost data obtained through the analysis of financial and inventory reports generated by the Defense Logistics Agency (DLA), FISC San Diego, and NADEP North Island. These activities interact with each other on a daily basis and represent a significant portion of the total Navy logistics activity in that area.

#### **G. ORGANIZATION OF THE THESIS**

The thesis is divided into three major sections. The first section is descriptive. It provides an introduction

to the study and presents background material. The second section outlines a systems approach to the study of logistics and introduces the total cost model. The third and final section summarizes the study, draws conclusions, and provides recommendations. The six chapters are briefly highlighted below:

Chapter II introduces the key DOD/Navy supply activities and presents a brief history of the NADEP/FISC merger.

Chapter III defines the logistics concept and introduces the total cost model that will be used in the evaluation of the partnership.

Chapter IV presents and discusses the relevant data to be analyzed in the study.

Chapter V provides the specific data analysis.

Chapter VI presents a summary of the study, draws conclusions from the data analysis and provides recommendations for possible future courses of action.

## II. BACKGROUND

### A. HISTORY OF THE DEFENSE LOGISTICS

Shortly after the end of World War II, a presidential commission chaired by former President Herbert Hoover recommended centralizing logistics support procedures within the DOD. As a result, the DOD started developing organizations to manage supplies and certain support services on behalf of all the armed forces.

Integrated management of supplies and services began in 1952 with the establishment of a joint Army-Navy-Air Force Support Center to manage identification of supply items. For the first time, the same item was being bought, stored, and issued by all the military services using a common nomenclature.[Nichols, 1992]

The DOD and the military services defined the material that would be managed on an integrated basis as "consumable," e.g., supplies that are not repairable and are consumed in normal use. Procurement of weapon systems, their components and other end-use equipment were reserved for the individual military services.

Commodities of consumable items were assigned to one military service to manage for all the services. Respective commodity managing agencies (also known as single-managers) were established between 1954 and 1956. They bought, stored and issued supplies, managed inventories, and forecasted requirements. The Army managed food and clothing, the Navy managed medical supplies, petroleum and industrial parts, and the Air Force managed electronic items. These single-manager agencies provided efficient support to the military services and showed substantial economies of operation.  
[Nichols, 1992]

Although these agencies displayed significant savings, they did not implement the uniform procedures that had been recommended by the Hoover Commission. Each single-manager

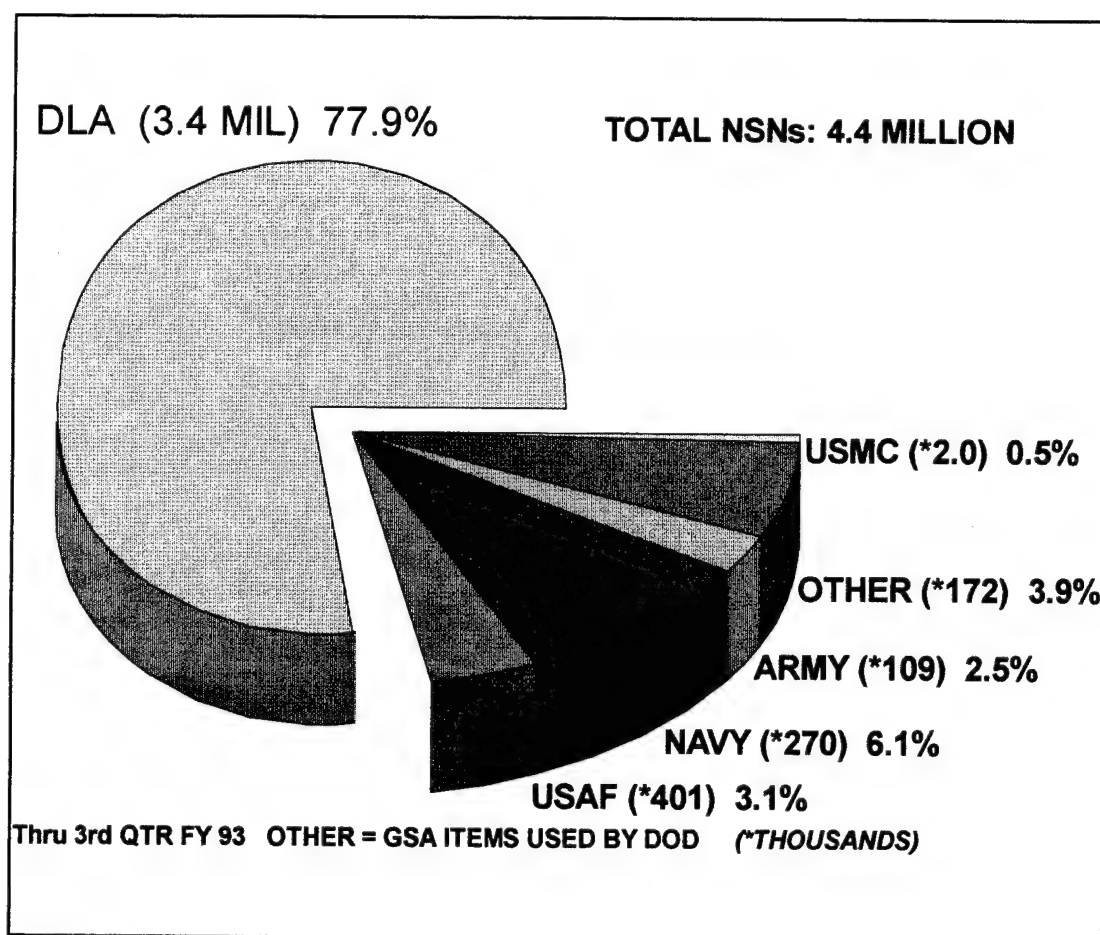
agency followed the established procedures of its own service. As a result, customers had to develop and use many different sets of procedures that varied from commodity manager to commodity manager. In 1961, Secretary of Defense Robert McNamara ordered that all the single-manager agencies be consolidated into one central agency.

The Defense Supply Agency (DSA) was established on October 1, 1961, and began operations January 1, 1962. During the first year of operations, eight single-manager agencies became DSA supply centers. In the following two years, four additional depots were transferred to the DSA. In 1965, the Defense Subsistence Supply Center, the Defense Clothing Center, and the Defense Medical Supply Center were merged to form the Defense Personnel Support Center, Philadelphia, Pennsylvania.

Another major consolidation occurred in 1965 when the DOD merged a significant portion of its contract administration activities. The Defense Contracts Administration Services (DCAS) was established (within the DLA) to manage the newly consolidated functions. This was an attempt to avoid unnecessary duplication of effort and to provide uniform procedures for administering contracts after award. The agency's new contracting administration duties gave it overall responsibility for the performance of most defense contracts, including some weapons systems and their components. The services retained separate contract administration authority for their state-of-the-art weapons systems.

In 1973, the agency's supply operations were extended to include overseas locations. The DSA was assigned responsibility for overseas wholesale food stocks and bulk fuel inventory. To reflect its broadened role in military logistics, the agency was renamed the Defense Logistics Agency (DLA).

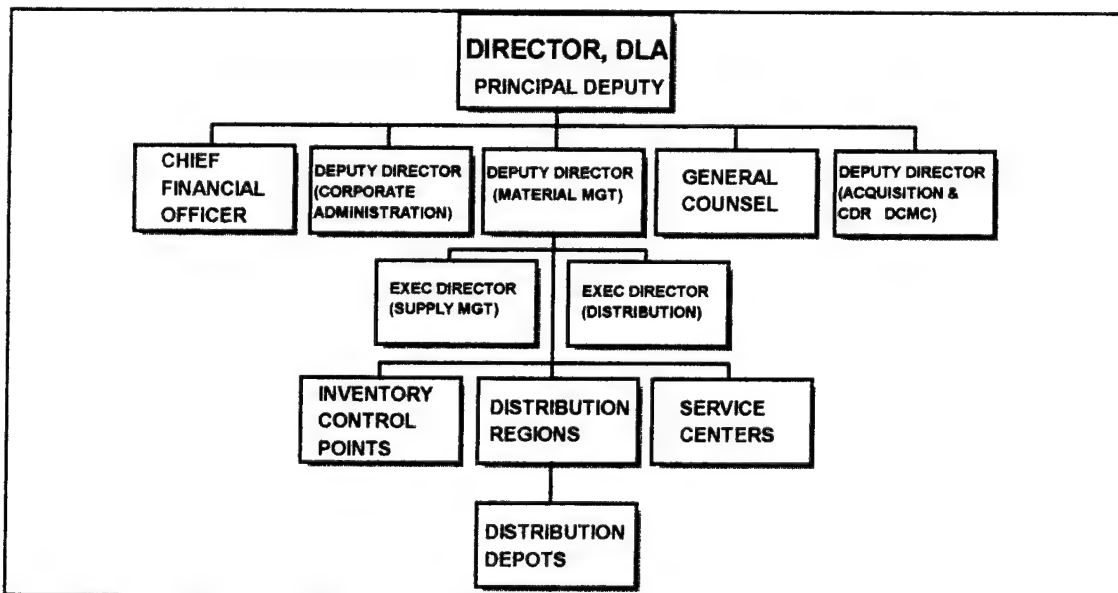
The volume of supply items managed by the DLA has been growing steadily. When the agency was first established, it was managing 1.2 million items. As Figure 1 depicts, today the DLA manages more than 3.4 million of the 4.4 million supply items used by the military services. This enormous increase in volume was the result of the Defense Management Review Decision (DMRD) 902 which directed the consolidation of continental U.S. service supply depots under the DLA. When the ongoing transfer of consumable items is complete, the DLA will be responsible for managing approximately 90 percent of military supply items.



**Figure 1** Total Supply Items Managed by Agency

In 1965, the DLA was delegated the administration of most contracts to avoid duplication of effort and provide uniform procedures in administering contracts after award. For this purpose, the Defense Contract Administration Services (DCAS), was established with the DLA to manage the Consolidated functions. The individual services retained contract responsibility for most major weapons systems and overseas contracts. This changed in 1990 when the DOD directed that virtually all contract administration functions be consolidated, and the Defense Contract Management Command (DCMC) was established within the DLA for this purpose. DCAS was absorbed into the new command.

In 1989, Secretary of Defense Dick Cheney directed that all the distribution depots of the military services and the DLA be consolidated into a single, unified material distribution system and designated the DLA as manager. The consolidation effort began in October, 1991 and was completed March 16, 1992. Figure 2 illustrates the current DLA organizational chart highlighting the material management functions.



**Figure 2** DLA Organizational Chart

As the defense budget is reduced, the military's logistics services continue to be under review as a source of monetary savings. Consolidations, mergers and partnerships are required in order to maintain vital services while reducing costs. Many military logistics functions were combined or eliminated during the Base Realignment and Closure (BRAC) process of 1993. Many more are expected to be combined as a result of BRAC 1995.

#### **B. HISTORY OF THE FLEET INDUSTRIAL SUPPLY CENTER, SAN DIEGO**

The history of the Fleet and Industrial Supply Center (FISC), San Diego traces back to the very beginning of Naval shore activity in the San Diego area. At the beginning of this century, the Navy's Fleet routinely anchored in the San Diego harbor at the foot of Broadway, making it the ideal location for a supply depot. The Naval Supply Depot (NSD) was officially commissioned on August 22, 1922 after the completion of Building 1 at the foot of Broadway on Harbor Drive. The first materials were moved into its warehouse in February 1923. Construction of other facilities was almost constant from the 1920's into the 1940's.[Markovinovic, 1992]

By 1959, the customer base had grown significantly. One of the major contributing factors for this increase occurred when the Naval Repair Facility in National City transferred its technical material and facilities to NSD San Diego. As a result, the Naval Supply Depot, San Diego was recommissioned as a Naval Supply Center (NSC) on September 18, 1959.

With the 1960's came automation and increased inventory awareness at the Center. Sophisticated material handling systems were installed which increased the flow of supplies while computers replaced traditional manual methods of processing vital information. The area's first Service

Market (SERVMART) was opened on October, 15, 1963 and was a revolutionary way of providing its customers with high usage supplies. Customers could now go to a retail store environment to purchase most administrative and cleaning supplies.

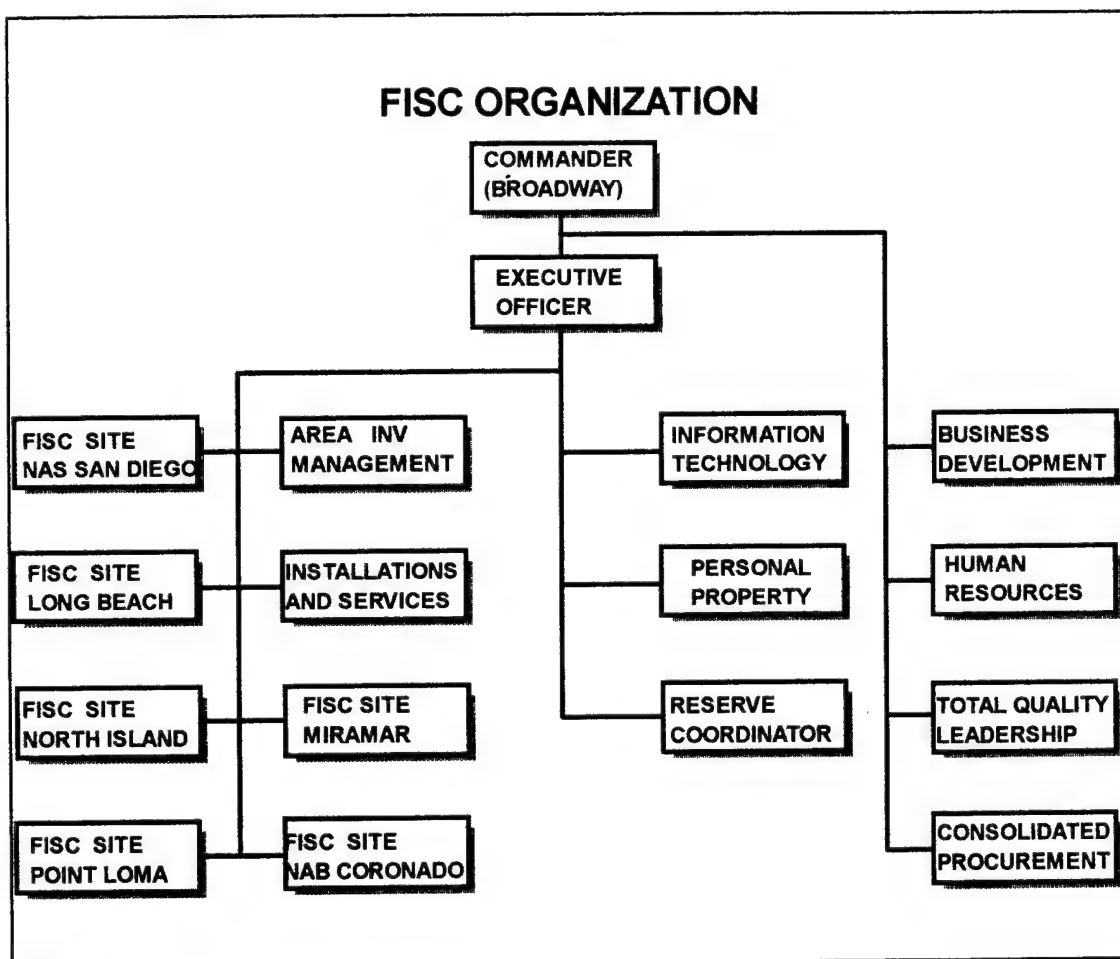
In 1973, when the Long Beach Naval Supply Center closed, the NSC San Diego again expanded its customer base. They assumed logistic support for Long Beach Naval Station, the 28 ships that operated in the area and the 22 local shore activities which included the Naval Shipyard.  
[Markovinovic, 1992]

In October 1980, as part of the Shore Establishment Realignment (SER) program, the Naval Air Station North Island Aviation Wholesale Support functions were assumed by NSC San Diego. NSC now provided support for the local area aviation community as well as worldwide aviation customers.

As a result of "right-sizing," NSC's physical distribution operations were transferred to the DLA under the Defense Distribution Depot (DDD), San Diego in 1992. NSC's payroll function was transferred to the Defense Finance and Accounting Center, Denver in July 1992. On August 25, 1992 NSC San Diego changed its name to the Fleet and Industrial Supply Center San Diego. As a result of this realignment, the FISC was no longer in the "inventory business" but was now totally in the "customer service/value added" business. Under the FISC concept, customers have a one-stop service center to take care of their entire range of needs. Requirements such as technical support, contracting, procurement, shipping, packaging and receiving are some of the activities performed by the FISC. Other operations include a fuel department, personal property department, regional mail distribution, and hazardous material management.

Today, the mission of the FISC San Diego is to

continuously shape the future by providing quality products and services to Fleet, Shore and Industrial customers through an innovative, talented and dedicated work force. It employs 23 military officers, four military enlisted and 779 civilian personnel. The Center's operations span to six separate locations (sites): Naval Station San Diego, Naval Air Station (NAS) North Island, Naval Air Station Miramar, Naval Amphibious Base (NAB) Coronado, Point Loma complex and the Naval Shipyard (NSY) Long Beach. Figure 3 illustrates the organizational structure of the FISC San Diego.



**Figure 3** FISC Organizational Chart

The FISC host functions are conducted at the Broadway Compound in downtown San Diego. The primary mission of the host is to support the sites by providing coordinated technical and administrative assistance. Other sites are designated as "lead sites" and perform a certain mission for all the sites. For example, the North Island FISC site "owns" the transportation mission for the entire region.

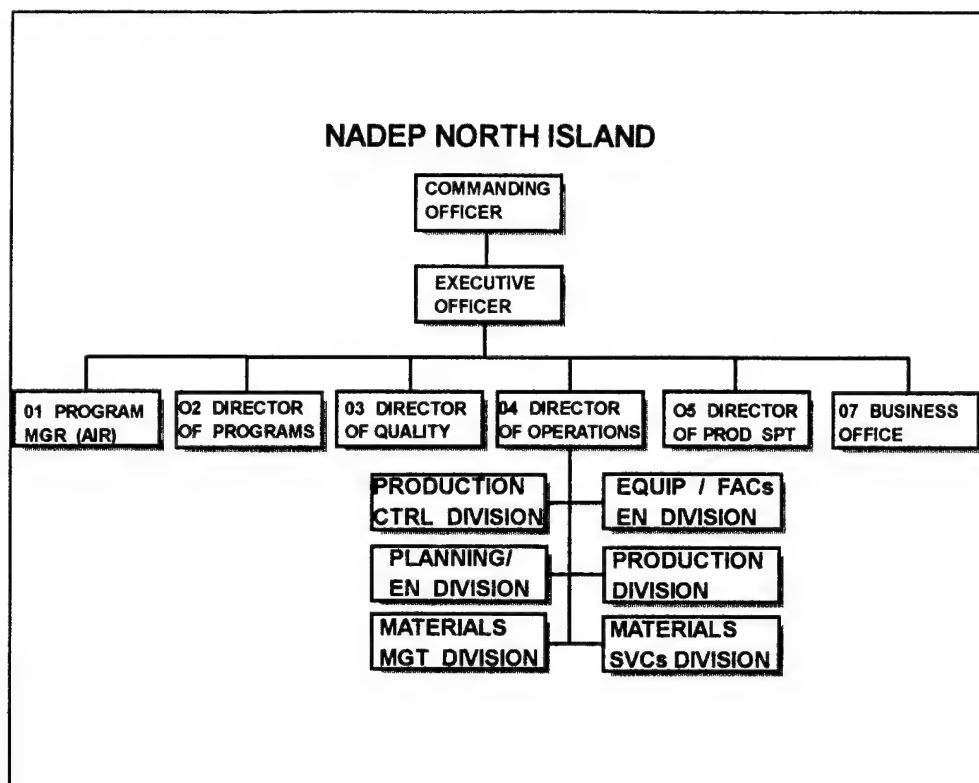
The annual economic impact on the San Diego area is significant. The payroll exceeds \$25 million, while contracting and procurement services are valued at more than \$82 million.[FISC San Diego Facts and Figures, 1994]

### **C. HISTORY OF THE NAVAL AVIATION DEPOT, NORTH ISLAND**

In 1910, only seven years after the Wright Brothers' first flight, a Curtiss airplane landed on North Island. That same year, North Island became the birthplace of naval aviation as Lieutenant Theodore Ellyson was the first naval officer to receive flight instruction at the Curtiss Aviation Camp.[Neel, 1994]

In 1917, the Naval Air Station, North Island was established. Recognizing the need to have an on-site repair facility at North Island, in 1919 the present day Naval Aviation Depot (NADEP) came into existence as the Aircraft and Repair Department of the air station. Repair work was done on locally operated aircraft.

In 1969, the department became a separate command and was commissioned the Naval Air Rework Facility (NARF), North Island. The NARF underwent another name change in 1987, and today it is known as the Naval Aviation Depot (NADEP), North Island. Figure 4 represents a portion of the organizational structure with emphasis on the Operations Division.



**Figure 4** NADEP North Island Organizational Chart

NADEP North Island's primary responsibility is to repair and modify aircraft, engines and components. The depot provides a number of specialized services not available anywhere else in the Navy.

The depot has the capacity to perform Standard Depot Level Maintenance (SDLM) on as many as 200 aircraft and 650 engines a year. Customers include the U.S. Navy, Air Force, Army and Marine Corps. Many foreign countries also utilize the NADEP North Island for aircraft repair, depot logistics and training.

In carrying out its mission of providing excellence in aviation maintenance, engineering and logistics support around the world, the NADEP has a significant impact on the

local economy. During fiscal year 1994, NADEP's payroll budget was \$156 million while the contracts and miscellaneous expenses totalled over \$32 million. [Neel, 1994]

#### **D. THE NADEP/FISC PARTNERSHIP**

In April 1992, NAVSUP proposed the concept of end user inventory consolidation. The primary reasons for this effort were:

1. Defense Management Review Decision (DMRD) 902 directed the consolidation of continental U.S. (CONUS) service supply depots under DLA. The NSCs no longer managed intermediate levels of inventory. End users went directly to DLA for most of their material requirements. NAVSUP was concerned that DLA could not provide the tailored customer service needs required by the fleet, so the FISC regional concept was developed. An element of this concept is the regional partnership idea.
2. The Navy depots had a history of poor performance in handling material. Merging them with "material experts" would decrease their logistic costs and decrease their cost charged to the customer. This could make them more competitive with their Air Force counterparts who were "stealing" business from the NADEP.
3. The decreasing budgets and manning necessitated the action be taken. Savings could be realized by eliminating inventory layers and sharing material via asset visibility.

During 1993, NAVSUP changed the name of their Naval Supply Centers to Fleet Industrial Supply Centers in an effort to facilitate the future concept.

Prior to the consolidation, the two commands established a Joint Quality Management Board (JQMB) designated specifically to investigate the feasibility of a merger. The JQMB used a phased approach in evaluating the possible transition. Individual areas of responsibility

were reviewed to decide which were the most practical for consolidation. These included, but were not limited to, inventory management, contract support, transportation, receiving, pre-expended bin operations, and hazardous material control.

On January 24, 1994, FISC San Diego and NADEP North Island officially "merged" several functional areas, including the Depot's Material Management and Material Services Division, into the FISC.[Markovinovic, 1994] The goal of the merger, as stated by the two partners, was to "optimize material support to enhance our ability to competitively produce quality products." [CDR Dolan, LCDR Zimmon, 1993] Together, the NADEP and FISC planners determined that material functions could be combined with an estimated savings to the depot of \$5 million in indirect labor and \$4 million in indirect non-labor expenses.

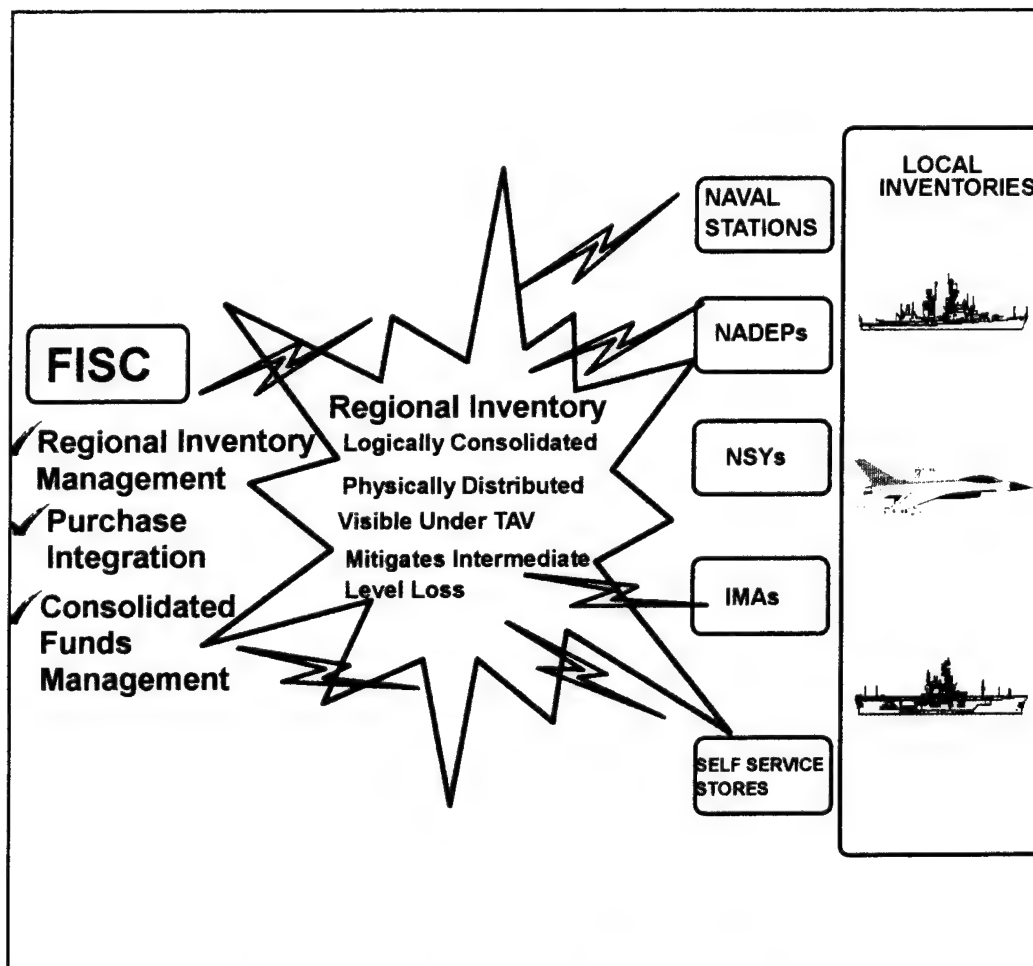
Once the prototype decision was approved, a six phase process was used to facilitate the execution of the merger:

- Determine the starting point within the NADEP
- Evaluate functions for transition
- Develop business rules
- Conduct operational tests
- Perform evaluations
- Recommend course of action

When completed, NADEP had transferred the Material Management and Material Services Divisions, consisting of 160 personnel, to the FISC. The underlying aspect of the transition was the "as is, where is" concept, which meant that no assets were moved from their original locations. The only major change was that the "new" FISC material division will fall under the Naval Supply Systems claimancy

instead of the Naval Air Systems Command.[CDR Dolan, LT Fisher, 1994]

This new, single, optimized "regional" inventory management concept should result in reduced overall inventories. Smaller safety levels should allow customers to share the risk of "stock-outs" rather than protecting each customer by providing redundant inventory support within the region. Aggregate demand on the low end should lead to a greater range of items carried in a geographic region, and thus enhance overall support in that region. Figure 5 illustrates the FISC Regional Support Concept.



**Figure 5** FISC Regional Support Concept

Replenishment, safety levels and inventory positioning decisions are based on economies gained by calculating single-region versus multi-site requirements. Requirements determination models will incorporate factors such as: historic demand, future program forecasts, and unique customer support parameters.[Smith, 1993]

#### **E. SUMMARY**

This chapter presented a brief history of the Defense Logistic Agency, the Fleet Industrial Supply Center San Diego, and the Naval Aviation Depot North Island. This background information was provided to illustrate the relationship of the three agencies and their correlation to the FISC/NADEP partnership. Additionally, we introduced the underlying reasons for the FISC/NADEP partnership and highlighted relevant background information on the consolidation effort.



### **III. THE LOGISTICS CONCEPT**

#### **A. INTRODUCTION**

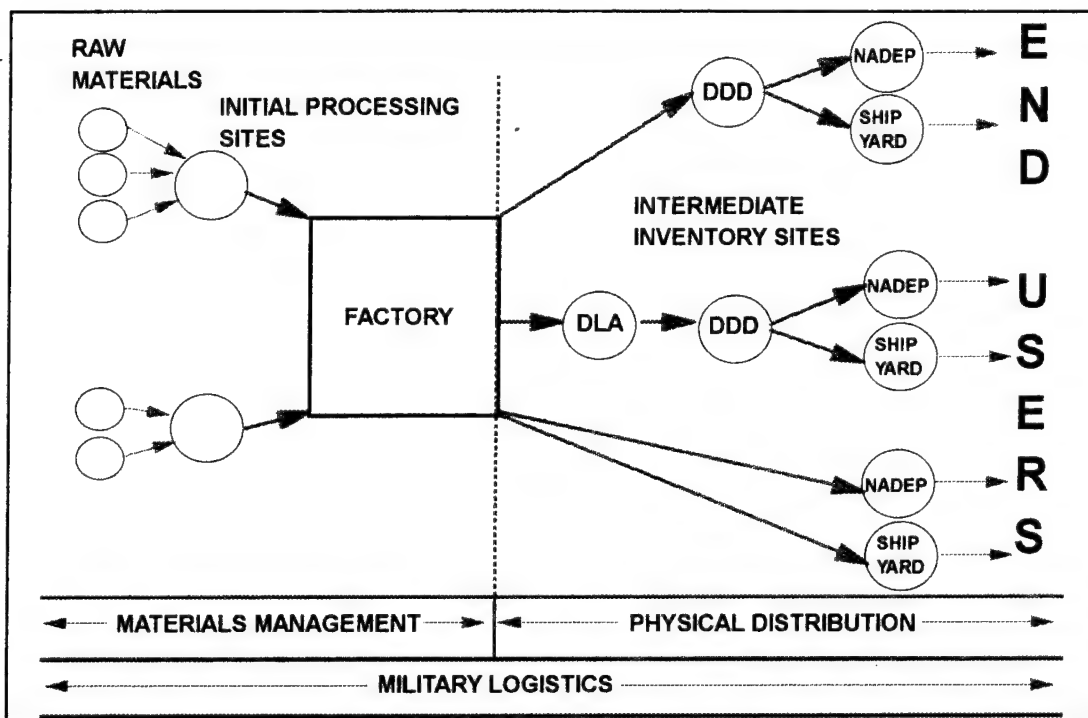
This chapter presents an overview of the key elements of the logistics system concept as it applies to this study. We also introduce the total cost model and define all relevant costs that comprise the model. Specifically, this model captures all distribution costs that pertain to the NADEP/FISC partnership and serves as the basis for which to conduct our analysis.

#### **B. LOGISTICS SYSTEM CONCEPT**

While conducting our research, we discovered that the terminology used when describing logistics activities is far from consistent. Even within the same reference, the terminology used in different chapters often varies substantially. Logistics management, business logistics, total distribution, and physical distribution are often used in describing the same activities yet are strategically chosen by an author to convey a specific idea or concept.

While many authors go to great length to provide concise definitions of these terms, the fact is that in actual practice these terms many times are used interchangeably. Each professional in this field has at least a slightly different interpretation of what each of these terms means... For this reason, terminology will not be an issue ... if it is assumed that there is some common understanding that any or all of these terms refer generally to a comprehensive set of activities relating to the movement and storage of product and information. These activities are all undertaken to achieve two common goals, namely, providing an acceptable level of customer service, and operating a logistics system to provide overall conformity to customer requirements.  
[Langley, 1986]

Professor Langley has provided us with a practical definition of the logistics concept. We have modified his definition slightly to include the following: *the concept of military logistics is the entire process of determining how much material to procure and where to store it. It also involves the subsequent movement of those materials from the manufacturer into, through an intermediate storage area, and on to the end user.* The logistics concept can be further broken into two major sequential processes (materials management and physical distribution) that include all other logistics activities and decision areas (see Figure 6).



**Figure 6** The Logistics Concept [Christopher, 1985]

The logistics system concept constitutes five basic decision areas: transportation, inventories, facilities, warehousing/consolidation, and communications. Costs in one area are often influenced by decisions in other areas; the logistics task is the search for trade-offs: the search for possibilities of total cost reductions

by changing the cost structure in one area.  
[Buijtenen, 1976]

## 1. Materials Management

As depicted in Figure 6, materials management encompasses all activities that enable raw materials to be processed at the factory. Although it is beyond the scope of this thesis, it deserves mention because it includes many of the same functions that occur in physical distribution. Specific examples include: material handling activities within the facility, intermediate warehousing and consolidation, inventory control and local transportation.[Johnson and Wood, 1990]

## 2. Physical Distribution

Physical distribution includes those activities that facilitate the movement of raw materials from the factory (and/or intermediate storage facility) to the end user (see Figure 7).[Blanchard, 1992]

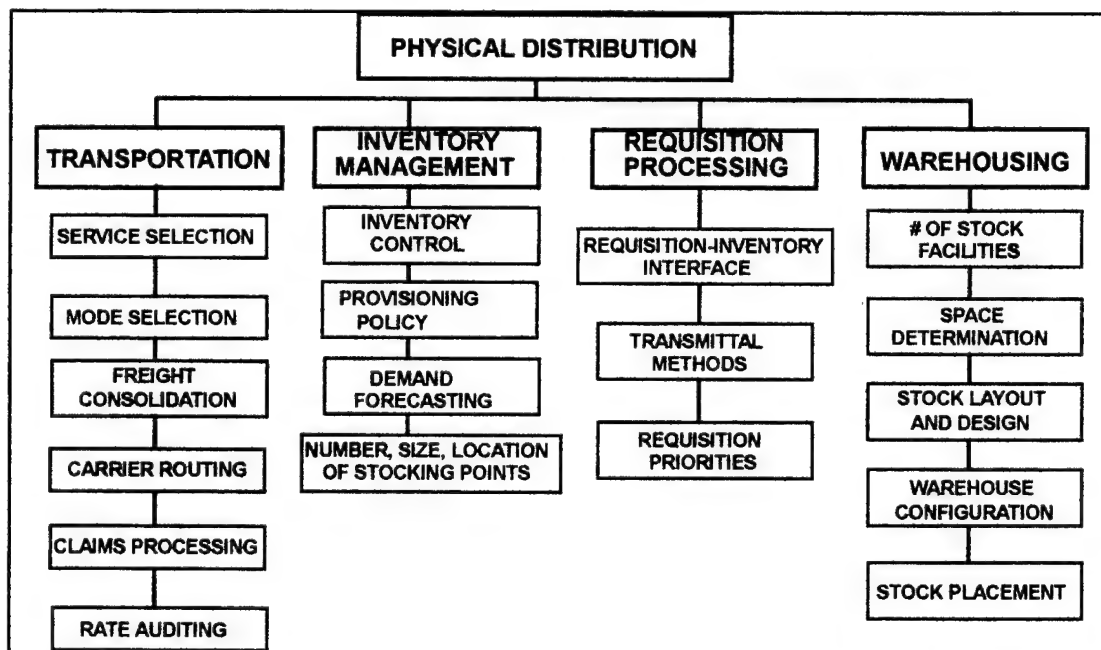


Figure 7 Physical Distribution Activities [Blanchard, 1992]

In the military, we commonly view physical distribution as being synonymous with the supply support process. For the purpose of this study, we define physical distribution as the process of planning, implementing, and controlling the flow of spare parts from the Inventory Control Point (ICP) to the individual end users. The key activities of this process include the following:

**a. Transportation**

Transportation support is required to move personnel and commodities from the origin to destination and between various intermediate storage facilities. The entire transportation function,<sup>1</sup> to include all its sub-activities, constitutes a vital link in the logistics systems concept. When evaluating the effectiveness of the logistics system, the following transportation factors must be considered:[Blanchard, 1992]

1. Transportation routes: from supplier to an intermediate storage facility, from supplier directly to end user, between intermediate storage facilities, and from an intermediate storage facility to an end user.
2. Transportation capabilities and restrictions: military carrier, commercial carrier, transportation mode, volume of goods (truckload shipments versus less than truckload shipments), frequency of shipments, and route restrictions.
3. Transportation time: priority of commodities and flexibility of service.
4. Transportation cost: cost per shipment, cost per carrier per mile, cost per carrier per truckload, and cost of obtaining non-routine transportation service.

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<sup>1</sup>For the purposes of this study, the definition of transportation includes all ancillary functions such as packaging, securing, and material handling services which are not expressly outlined in Figure 7.

With the advent of intermodal transportation,<sup>2</sup> the costs incurred when shipping commodities has decreased dramatically over the last ten years. In fact, the recently established Guaranteed Traffic Agreement between the DOD and private carriers has created a "free for all" rate structure and long-term transportation support agreements.

The climate has never been better for the government to ship a steady flow of items with a carrier that needs to fill its under-utilized trucks or rail cars. These negotiations work best when both parties profit in some manner--lower rates for the government and higher asset utilization rates for the carrier.[Basinger, 1994]

These mutually beneficial relationships have been partly responsible for significantly reducing transportation costs as a percentage of the total logistics cost. The other factor is the tremendous improvement in transportation technology. Carriers have simply been able to transport more commodities at a faster rate, using fewer assets. As a result, transportation costs are not considered as a trade-off decision area but rather a variable to be included in the total cost model.

#### **b. Inventory Management**

Inventory management consists of many functions. We will briefly explore the ones which pertain to our study. These include inventory control, provisioning policy, demand forecasting, and various warehousing decisions.

Inventory control is often comprised of being able to maintain a balance between various conflicting costs. The balance is achieved when a unit is able to maintain a minimum level of stock with respect to a specified level of

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<sup>2</sup>Intermodal transportation: the planned, deliberate, and efficient transfer of commodities between two or more different modes of transportation.[Muller, 1989]

customer service. In this instance, the risk of running out of stock is increased as the inventory level is reduced and subsequent stock-outs equate to a decrease in unit readiness. The main goal of inventory management is to provide a buffer between uncertain supply and demand, at minimum cost.

There are many reasons for having inventories. Some economic reasons are:

- To reduce administrative order costs
- To gain quantity discounts on unit price
- To reduce shortage costs
- To obtain transportation discounts
- To reduce maintenance cycle time
- To avoid costly future rebuild of production lines

Some military reasons are:

- To increase readiness of combat systems
- Combat usage rate is greater than peacetime production rate
- To sustain ships at sea
- To secure instant availability needed to prevent death
- To sustain operations until industry can begin production
- To deal with uncertainty (safety stock)

The objective of inventory management, in the military, is to "provide the right material and services to the right place and time to keep the Navy's people and equipment operating at the specified level, while minimizing the cost to do so." [Moore, 1994] The NADEP/FISC partnership, and

other end user inventory consolidations, are examples of some of the recent efforts being undertaken to achieve this goal.

Inventory control is vital to any organization which holds stock. All stock holdings incur costs, which typically amount to 25% of the value of inventory held for a year. The Navy uses a holding cost rate of 23% for consumable items and 21% for repairables.[McMasters, 1994]

The two percent difference between these rates is due to a theft and shrinkage factor included in the consumable item rate. At roughly 25% of inventory costs, holding stock is expensive, but inventory shortages can result in even higher costs. In a non-military environment, these shortages usually translate to lost sales, negative publicity, and lost potential customers. In the military, shortages have a more immediate impact. Stock-outs directly hinder a unit's ability to go to war. The standard classification of stock holding costs includes:

1. Unit cost: The price charged by a supplier for the purchase of an item.
2. Reorder cost: The cost of placing a repeat order for the item.
3. Holding cost: The time value of money, warehousing, obsolescence, and theft and shrinkage.
4. Inventory shortage (stock out) cost: The cost incurred by not having the item in stock. This cost is extremely difficult to measure accurately. Shortage costs can range from minor degradation of a redundant system, to loss of mission, loss of battle, or loss of war.

The formulation of an inventory policy tends to be a very complicated process. Directives specifying the range and depth of initial spares and repair parts are computed in accordance with the DOD Instructions 4140.42, 4140.40, and

OPNAV Instruction 4423.4. The decision to stock an existing item is comprised of many variables. They include:

- Essentiality codes
- Demand-based item versus non demand-based
- Insurance items
- Minimum replacement unit
- Demand history
- Interim support
- Safety levels

There are many models available to help determine the "optimal" stock level. The Navy currently uses the Mean Supply Response Time model and the Variable Threshold model to decide whether to stock an item and at what level.

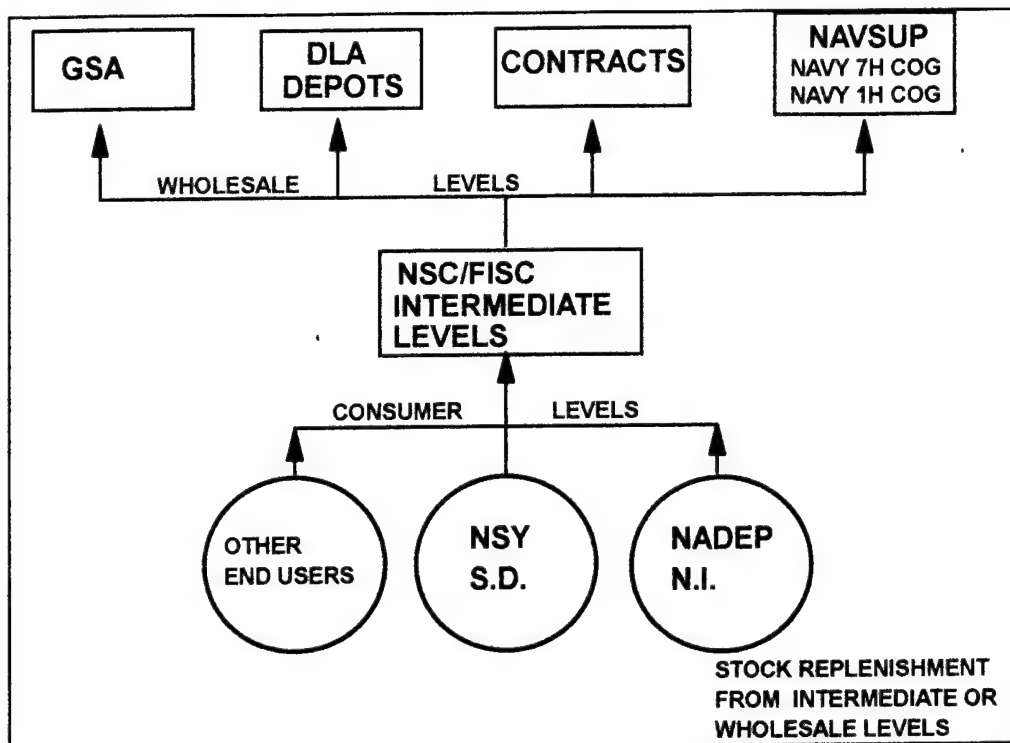
Demand forecasting is another element of inventory management. Different forecasting models can be used to predict future demand of consumable items and depot level repairables. In the case of consumables, the purpose of forecasting is to predict demands over a pre-determined procurement lead time. For depot level repairables, forecasting is also used to predict demand over procurement lead time but takes the regeneration from repairs into account. For example, if demand for a repairable radar is predicted to be 100 in the next year, and the item has a 90% repair rate, then at least 10 new radars will have to be procured next year. This example is very simplified. The Ship Parts Control Center (SPCC) and the Aviation Supply Office (ASO) have computer models which they use to predict future demand and make procurement decisions. These models are used to anticipate wholesale inventory requirements. End users, such as NADEP, influence the forecasts through recurring demand and planned maintenance. These components

remain somewhat stable and can be adequately predicted. As with other segments of inventory management, it is difficult to use demand forecasting to maintain appropriate inventory levels with uncertain and unforeseen demand.

The final point of inventory management to be discussed is the physical location, size, and number of stocking points (warehouses). In the past, the number of inventory facilities (as well as location and size) was determined by the individual services. Local demand was the major determining factor as to where to place stock. Today, local demand continues to be the principal factor in location determination, but has become harder to predict because of the continued increase in the number of "local" customers. The combination of more customers and reduced stocking points make supply operations very challenging in the future. (The warehousing function is discussed in further detail in subsection d.)

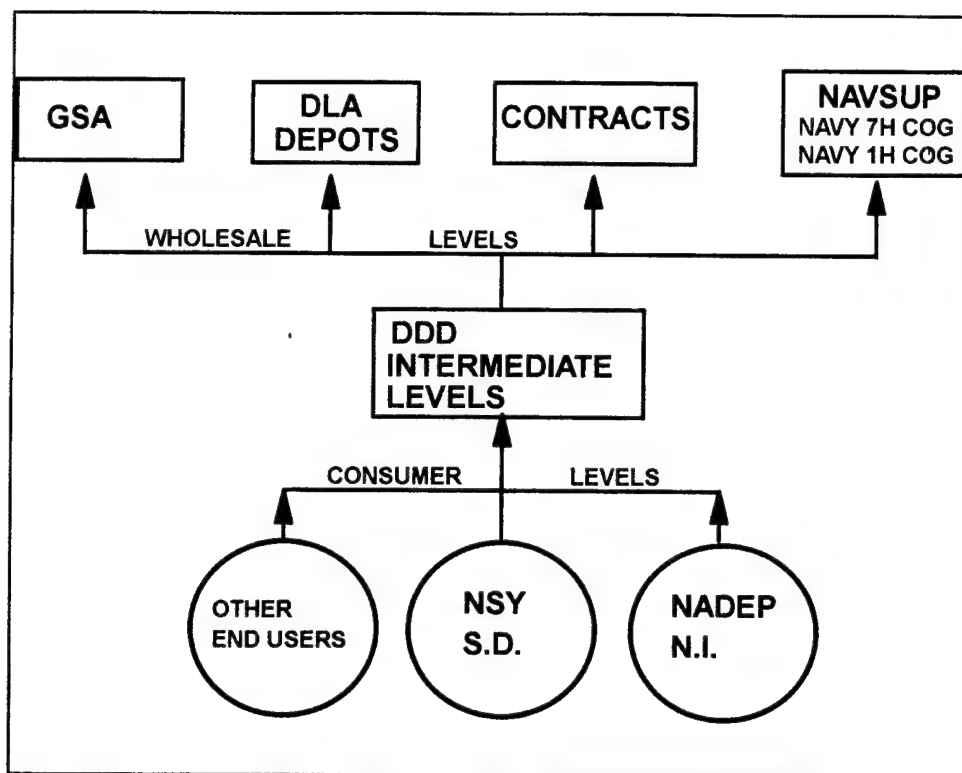
### ***c. Requisition Processing***

Requisition processing has undergone two major changes over the last few years. Prior to DMRD 902, when NADEP maintenance technicians would request a repair part, they would complete the requisition forms and submit them to the Material Services Division. If the item was available from NADEP stock, the issue was made and the demand data recorded. If the item was not in stock or not carried in inventory, the requisition would be passed to the NSC (and later FISC) for issue from their intermediate level of supply. If the component was not available at the intermediate source of supply, then the requisition was passed to the wholesale supply level for issue or back order. Stock replenishment of NADEP's inventory could be achieved at either the intermediate or wholesale levels. Figure 8 exhibits this process.



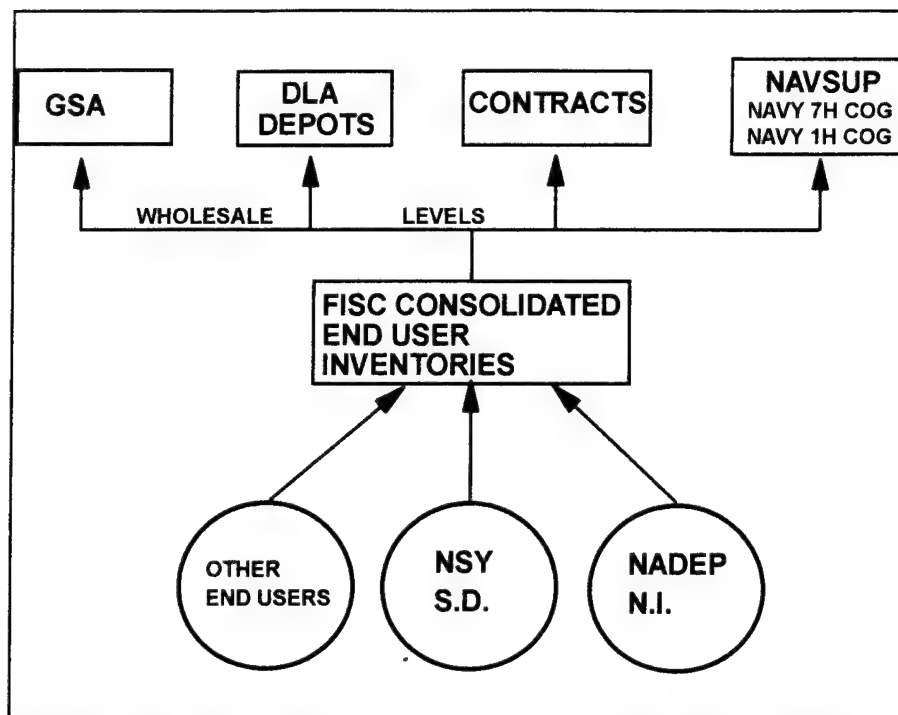
**Figure 8** Requisition Process before DMRD 902

After DMRD 902, the FISCs no longer managed intermediate inventory levels. This reorganization was transparent to the end user customer such as NADEP. In most cases, the inventory remained in the same locations but changed "owners." DLA now had responsibility of material management and the Defense Distribution Depots (DDD) managed the intermediate inventory levels. Figure 9 depicts this change.



**Figure 9** Requisition Process After DMRD 902

The NADEP/FISC partnership resulted in a second change in the requisition process. With this merger, NADEP no longer managed or "owned" its own end user stock. This change was similar to the first one in that the inventory locations and personnel did not relocate. All end user inventories in a geographic region were consolidated. Now the FISC has assumed management responsibility for end user inventories. Figure 10 shows the current requisitioning process for FISC partners.



**Figure 10** Requisition Process After End User Consolidation

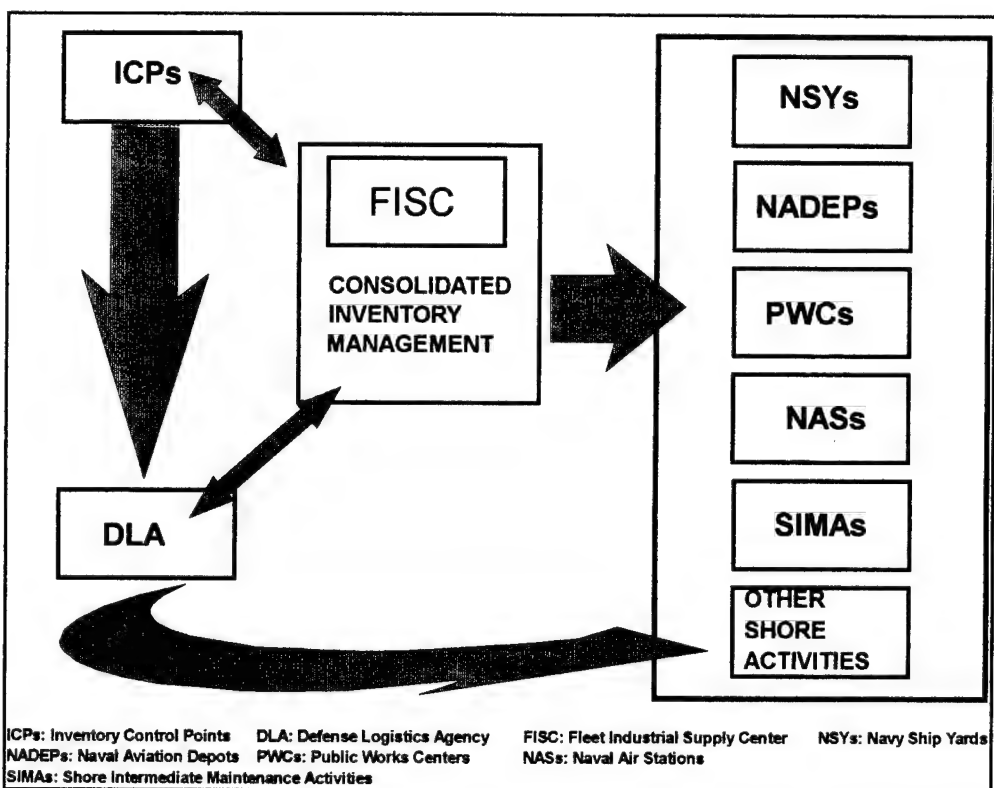
#### **d. Warehousing**

The warehousing function is typically conducted to temporarily store items that are enroute to the end user.[Ballou, 1992] The primary objective is to coordinate and integrate all storage activities in such a way as to maximize customer service in the most cost efficient manner. Under the FISC concept, inventory management would no longer be executed at the NADEP or shipyard level. As stated earlier, logistics management is now the primary responsibility of the FISC. Figure 11 depicts the consolidated management of distributed end user inventories at the FISC level.

Storage facilities are required to support activities which pertain to the accomplishment of active maintenance tasks, thus providing warehousing functions for spares and

repair parts. Although specific quantitative measures associated with facilities may vary significantly from system to system, the following factors must be considered:[Blanchard, 1992]

1. Customer Service Level is the total time required to place an order to the time it takes to deliver it to the end user.
2. Facility Utilization is the ratio of the time a facility is utilized to the total time a facility is available for use (usually stated in a percentage of space occupied).
3. Energy Utilization is the cost of utilities and other miscellaneous expenses.
4. Total Facility Cost is the total cost of operating a storage facility (usually stated in cost per activity per month).



**Figure 11** The FISC CONCEPT

### C. TOTAL COST CONCEPT

In order to determine the effectiveness and efficiency of a particular distribution system, we must develop a model that measures the relevant performance criteria upon which to base our analysis. Central to the scope and design of this model is the need to conduct a total cost trade-off analysis<sup>3</sup>.

By merely conducting a trade-off analysis, we recognize the existence of various conflicting objectives within the physical distribution system. The difference between the efficiency of individual inventory stock points and the effectiveness of the entire physical distribution system, as a whole, reflects the underlying conflict among the various different distribution activities.[Magee, 1967]

The military logistician's primary objective is to ensure that the defense supply system can produce a sufficient amount of spare parts to support the on-going maintenance effort. In other words, the primary mandate of the logistician is to minimize the number of items that are carried as non-mission capable (in an awaiting parts status) but at the same time, keep inventory levels to a minimum.

Maintenance managers, on the other hand, tend to welcome the idea of having large well-stocked warehouses, carrying a wide assortment of parts, at their immediate disposal. However, the interests of the Navy are best served by an effective and efficient distribution system that enables us to achieve an optimal balance between the need for improved customer service and the need for an overall reduction in physical distribution costs.

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<sup>3</sup>A trade-off occurs where an increased cost in one distribution activity is more than matched by a cost reduction in another, thus leading to an improved situation overall.[Christopher, 1985]

## **1. The Total Cost Approach**

Historically, the DOD has only considered tangible costs that were readily measurable (i.e., transportation and warehousing costs) as constituting its physical distribution costs. Under the recently adopted total distribution system, it now recognizes that there are many more costs incurred in sustaining its physical distribution system. For example, decisions about unit readiness (customer service level) affect the amount of inventory that must be stocked, at some supply activity within the distribution system, to ensure that the parts are available when needed.

These costs, depicted in the example above, comprise *inventory holding costs* and are incurred as a result of physically maintaining a specified inventory level. These costs, and others outlined in the following section, must be included when determining total distribution costs.

The total cost approach is built on the premise that all relevant functions in moving and storing materials and products should be considered as a whole and not individually. The following activities must be included in the total cost analysis:[Johnson and Wood, 1990]

- a. Transportation
- b. Warehousing (holding costs)
- c. Facilities
- d. Material handling
- e. Information flow
- f. Customer service level

## **2. The Total Cost Model**

Generally, the effects of the various cost trade-offs are assessed in two ways: first, from the impact upon total

distribution costs and second, from their impact upon sales revenue. We have modified the second criterion to address the impact upon customer service (unit readiness) instead of sales revenue. This is a more valid criterion because the end user's mission is the most important impetus for the entire logistics system.

It is possible to trade off various distribution costs in such a way as to increase total costs. In most cases, however, the improvement in unit readiness outweighs the increase in total costs. Also, the possibility exists of trading off costs between the various inventory holding activities. Thus, inventory levels can be reduced through consolidation whereby the holding costs are charged to another activity. The result is an increase in customer service at a lower total cost.

For the purposes of this study, we define the total cost model as the end product of a trade-off analysis comprised of the sum total of all relevant distribution costs that when combined (not individually) optimize the efficiency and effectiveness of the physical distribution system. The physical distribution total cost model can be expressed in the following equation:[Brown, 1994]

$$\text{TDC}=\text{TC}+\text{FC}+\text{IC}+\text{HC}+\text{SC}$$

where:

TDC= Total Distribution Costs

TC= Transportation Costs (protective packaging, material handling activities)

FC= Facilities Costs (depots, warehouses, etc.)

IC= Information and Communication Costs (order processing)

HC= Inventory Holding Costs (space costs, capital costs)

SC= Stock-out Costs (cost of degraded unit readiness)

#### D. SUMMARY

The purpose of this chapter was to provide a brief synopsis of the various components of the logistics system and to introduce a cost model with which to measure the effectiveness of the NADEP/FISC partnership. In this chapter, we defined the logistics concept as being the entire process of moving materials from the manufacturer, into and through intermediate storage areas, and on to the end user. We stated that the logistics system was divided into two major phases (materials management and physical distribution) that were comprised of five decision areas: transportation, inventories, facilities, warehousing/consolidation, and communications. We then defined the physical distribution function, highlighted all important sub-activities and discussed why they were of particular importance to the DOD.

Finally, we introduced the total cost concept, discussed the various trade-offs associated with the physical distribution process, and presented the total cost model upon which we will base our subsequent analysis.



#### **IV. PRESENTATION OF DATA**

##### **A. INTRODUCTION**

The purpose of this chapter is to present two physical distribution alternatives and determine which scenario is the most cost efficient by applying the total cost model developed in Chapter III. In the first scenario, we will ascertain the total distribution cost for an item where five end users maintain separate inventories. In contrast, the second scenario examines the total distribution costs for the same item while under the regional consolidation of the local FISC. As our data and model will show, inventory consolidation and total distribution cost (TDC) savings may not always be synonymous.

##### **B. MODEL PARAMETERS**

The formulas to derive the total distribution cost model are presented in Figure 12. These parameters are the basis for determining the total distribution cost for both alternatives. Under this model we state that the total distribution cost is a function of the reorder quantity and reorder point. Furthermore, these decision variables are equal to the sum of the holding cost, set up cost, and stock out cost. The system parameters in this model are item demand, holding cost rate, set up cost, procurement lead time, and unit cost.

The fictitious part, which we will call a "flux sensor," is a consumable item with a unit cost of \$1,500.00 and unit weight of 250 pounds. The demand data for the past three years has been formulated and shows a decreasing trend. This trend is representative of today's "right-sized" military.

The holding cost rate is comprised of warehousing cost, time value of money, obsolescence, and theft and shrinkage.

The associated costs for these factors are a percentage of the unit cost. Set up cost entails the transportation cost and administrative order cost which we have set at \$3.00 per order. Procurement lead time is the number of days from the time an order is placed to the time it is received. .

```

Model Parameters:[Brown, 1994]

Avg Lead time in years (mLT): .06 (21 days)

Lead time Variance in yrs (r2LT): .01 (4 days)

Lead time Standard Deviation, in years (rLT): .12 (44 days)

Standard deviation of yearly demand = rD

Unit Cost: $1500

Reorder Point: mD x mLT + SS

Service Level (SL): .9      1-SL: .1

Avg Demand during Lead time (mddlt): mD x mLT

Standard deviation demand during lead time (rddlt):  $\sqrt{mLT \times r2D + m2D \times r2LT}$ 

Safety Stock (SS): SS/rddlt, where:  $SS/rddlt = Z^{-1}[Q \times (1-SL)]/rddlt$ 

Unit Weight (lbs): 250

Unit Hundred Weight (cwt.): 2.5

EOQ:  $\sqrt{(2 \times mD \times S)/HC}$ 

Total Distribution Cost: HC + S + SC where:

a. Holding Costs (HC):[McMasters, 1994]
   Time Value of Money 0.10
   Warehousing: 0.01
   Obsolescence: 0.10
   Theft, Shrinkage: 0.02
   HC= 0.23

b. Set Up Costs (S):
   Transportation costs (TC):[Ballou, 1992]
   Ordering Costs (SC): $3.00

c. Stock Out Costs (SC): .1[Brown, 1994]

Transportation:      Distances (miles)[ICC HGB 100-C, 1987]      Rates:[Ballou, 1992]

DDD to FISC                      1.2                      0.86
FISC to NAS MIRAMAR              13.0                     0.86
FISC to NAS SAN DIEGO            1.2                      0.86
FISC to NSY LONG BEACH          107.0                     1.18
FISC to NAB CORONADO              6.8                      0.86
FISC to NADEP NORTH ISLAND       4.6                      0.86

```

Figure 12 TDC Model Input Parameters

### C. END USER INVENTORY MANAGEMENT SCENARIO

This case examines distribution costs for the flux sensor managed by five separate end users. The activities selected are in the San Diego area and have recently executed partnership arrangements with FISC San Diego. These activities; NSY Long Beach, NAB Coronado, NAS Miramar, NADEP North Island, and NAS San Diego; also managed their own end user inventory prior to the consolidation (see Figure 13).

The monthly demand for the flux sensor has been forecasted for each of the five activities. Additionally, the set up, holding, and stock out costs have also been calculated. Once this information has been determined, the total distribution cost for each location is then formulated. Finally, the end users total distribution costs are then summed to provide us with the overall total distribution cost to manage the flux sensor. Figures 14 through 18 present the data and resulting total distribution cost for the five activities. Figure 19 compares the total distribution costs of the five end users.

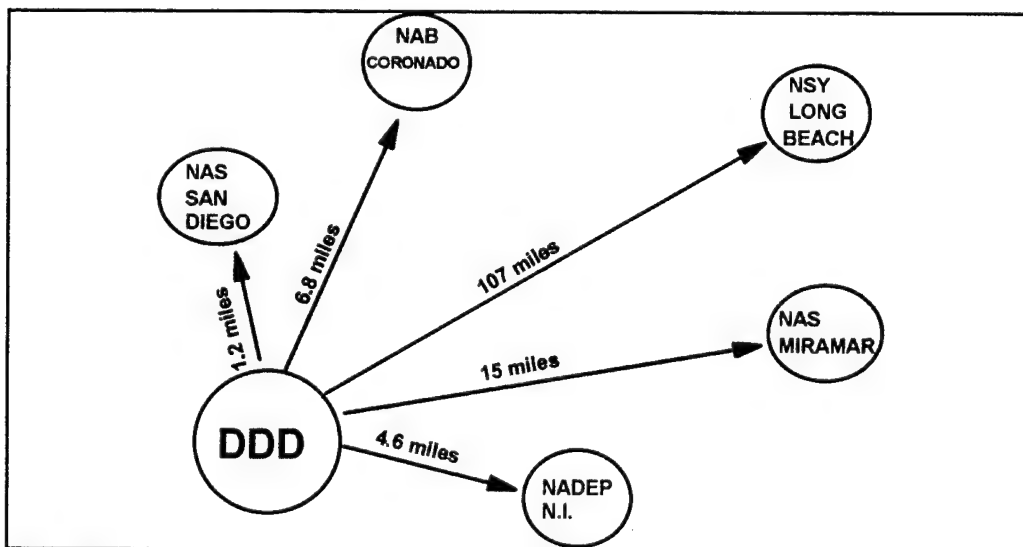


Figure 13 End Users Maintaining Separate Inventories

# NAS SAN DIEGO

## Demand History:

	year 1	year 2	year 3
JANUARY	2	3	2
FEBRUARY	4	3	3
MARCH	4	2	2
APRIL	3	3	4
MAY	4	3	3
JUNE	4	2	2
JULY	2	3	1
AUGUST	1	2	2
SEPTEMBER	2	3	3
OCTOBER	2	2	2
NOVEMBER	3	2	2
DECEMBER	2	2	2
Yearly Demand:	33	30	28
Avg Yrly Demand:	30.33 (mD)		920.11 (m2D)
Demand Variance:	6.33 (r2D)		
Standard Deviation:	2.52 (rD)		

Set Up Costs (S):	Distance= 1.2			
Transportation Costs (TC):	0.86	x	2.5	2.15
Order Costs:				<u>3</u>
			S=	5.15

## Holding Costs (HC):

Warehousing (FC):	1.00%	15
Time Value of Money:	10.00%	150
Obsolescence:	10.00%	150
Theft, Shrinkage:	2.00%	<u>30</u>
	HC=	345

Stock Out Cost (SC):	10.00%	150
----------------------	--------	-----

EOQ:	0.95
rddlt:	3.10
SS/rddlt=E-1[Qx(1-SL)]/rddlt=	0.03
E-1[.03]=	1.49

SS/rddlt:	1.49
SS:	4.61
ROP:	6.43

$$TDC(Q,ROP)=(mD/Q \times S) + (Q/2 \times HC) + (SS \times HC) + (SC \times mD/Q \times rddlt \times E[SS/rddlt])$$

$$TDC(Q,ROP) = 164.16 + 164.16 + 1591.16 + 455$$

$$TDC = \$2,374.47$$

Figure 14 NAS San Diego TDC Summary

# NAS MIRAMAR

## Demand History:

	year 1	year 2	year 3
JANUARY	3	4	2
FEBRUARY	3	3	3
MARCH	4	4	2
APRIL	3	3	4
MAY	4	3	3
JUNE	4	4	2
JULY	2	3	3
AUGUST	3	2	2
SEPTEMBER	2	3	3
OCTOBER	4	2	3
NOVEMBER	3	2	2
DECEMBER	1	2	3

Yearly Demand:	36	35	32
Avg Yrly Demand:	34.33 (mD)		1178.78 (m2D)
Demand Variance:	4.33 (r2D)		
Standard Deviation:	2.08 (rD)		

Set Up Costs (S): Distance= 15

Transportation Costs (TC):	0.86	x	2.5	2.15
Order Costs:				<u>3</u>
			S=	5.15

## Holding Costs (HC):

Warehousing (FC):	1.00%	15
Time Value of Money:	10.00%	150
Obsolescence:	10.00%	150
Theft, Shrinkage:	2.00%	<u>30</u>
	HC=	345

Stock Out Cost (SC): 10.00% 150

EOQ:	1.01
rddlt:	3.47
SS/rddlt=E-1[Qx(1-SL)] / rddlt=	0.03
E-1[.03]=	1.49

SS/rddlt:	1.49
SS:	5.17
ROP:	7.23

$$TDC(Q,ROP) = (mD/Q \times S) + (Q/2 \times HC) + (SS \times HC) + (SC \times mD/Q \times rddlt \times E[SS/rddlt])$$

$$TDC(Q,ROP) = 174.64 + 174.64 + 1784.26 + 515$$

$$TDC = \$2,648.55$$

Figure 15 NAS Miramar TDC Summary

NAB CORONADO			
	year 1	year 2	year 3
	2	3	2
JANUARY	2	2	3
FEBRUARY	1	2	3
MARCH	3	2	4
APRIL	4	3	3
MAY	3	2	2
JUNE	2	3	1
JULY	3	2	2
AUGUST	2	3	3
SEPTEMBER	3	2	2
OCTOBER	3	2	2
NOVEMBER	<u>2</u>	<u>3</u>	<u>1</u>
DECEMBER			
Yearly Demand:	30	29	28
Avg Yrly Demand:	29.00 (mD)		841.00 (m2D)
Demand Variance:	1.00 (r2D)		
Standard Deviation:	1.00 (rD)		
Set Up Costs (S):	Distance= 6.8		
Transportation Costs (TC):	0.86	x	2.5
Order Costs:			2.15
			<u>3</u>
		S=	5.15
Holding Costs (HC):			
Warehousing (FC):	1.00%		15
Time Value of Money:	10.00%		150
Obsolescence:	10.00%		150
Theft, Shrinkage:	2.00%		<u>30</u>
	HC=		345
Stock Out Cost (SC):	10.00%		150
EOQ:	0.93		
rddlt:	2.91		
SS/rddlt= E-1[Qx(1-SL)] / rddlt=		0.03	
E-1[.03]=		1.49	
SS/rddlt:	1.49		
SS:	4.34		
ROP:	6.08		
TDC(Q,ROP)=(mD/Q x S) + (Q/2 x HC) +(SS x HC) + (SC x mD/Q x rddlt x E[SS/rddlt])			
TDC(Q,ROP)	= 160.51	+ 160.51	+ 1496.05 + 435
TDC	= \$2,252.07		

Figure 16 NAB Coronado TDC Summary

# NSY LONG BEACH

## Demand History:

	year 1	year 2	year 3
JANUARY	2	3	3
FEBRUARY	3	3	3
MARCH	3	2	2
APRIL	3	4	4
MAY	4	3	3
JUNE	3	3	2
JULY	2	3	1
AUGUST	3	4	2
SEPTEMBER	3	3	3
OCTOBER	2	3	2
NOVEMBER	3	3	2
DECEMBER	<u>3</u>	<u>2</u>	<u>3</u>
Yearly Demand:	34	36	30
Avg Yrly Demand:	33.33 (mD)		1111.11 (m2D)
Demand Variance:	9.33 (r2D)		
Standard Deviation:	3.06 (rD)		

Set Up Costs (S):	Distance= 107			
Transportation Costs (TC):	1.18	x	25	2.95
Order Costs:				<u>3</u>
			S=	5.95

## Holding Costs (HC):

Warehousing (FC):	1.00%	15
Time Value of Money:	10.00%	150
Obsolescence:	10.00%	150
Theft, Shrinkage:	2.00%	<u>30</u>
	HC=	345

Stock Out Cost (SC):	10.00%	150
----------------------	--------	-----

EOQ:	1.07
rddlt:	3.42
SS/rddlt=E-1[Qx(1-SL)] / rddlt=	0.03
E-1[.03]=	1.49

SS/rddlt:	1.49
SS:	5.09
ROP:	7.09

$$TDC(Q,ROP) = (mD/Q \times S) + (Q/2 \times HC) + (SS \times HC) + (SC \times mD/Q \times rddlt \times E[SS/rddlt])$$

$$TDC(Q,ROP) = 184.97 + 184.97 + 1756.15 + 500$$

$$TDC = \$2,626.08$$

Figure 17 NSY Long Beach TDC Summary

# NADEP NORTH ISLAND

## Demand History:

	year 1	year 2	year 3
JANUARY	5	4	3
FEBRUARY	4	4	3
MARCH	4	3	2
APRIL	3	3	4
MAY	4	3	2
JUNE	4	3	2
JULY	2	3	1
AUGUST	4	3	2
SEPTEMBER	4	4	3
OCTOBER	2	3	2
NOVEMBER	4	2	3
DECEMBER	<u>4</u>	<u>2</u>	<u>2</u>
Yearly Demand:	44	37	29
Avg Yrly Demand:	36.67 (mD)		1344.44 (m2D)
Demand Variance:	56.33 (r2D)		
Standard Deviation:	7.51 (rD)		

Set Up Costs (S): Distance= 4.6

Transportation Costs (TC): 0.86 x 2.5 = 2.15  
 Order Costs: 3  
**S= 5.15**

## Holding Costs (HC):

Warehousing (FC):	1.00%	15
Time Value of Money:	10.00%	150
Obsolescence:	10.00%	150
Theft, Shrinkage:	2.00%	<u>30</u>
	<b>HC=</b>	<b>345</b>

Stock Out Cost (SC): 10.00% 150

EOQ: 1.05

rddlt: 4.10

SS/rddlt =  $E - 1[Q \times (1 - SL)] / rddlt =$  0.03  
 $E - 1[.03] =$  1.49

SS/rddlt: 1.49

SS: 6.11

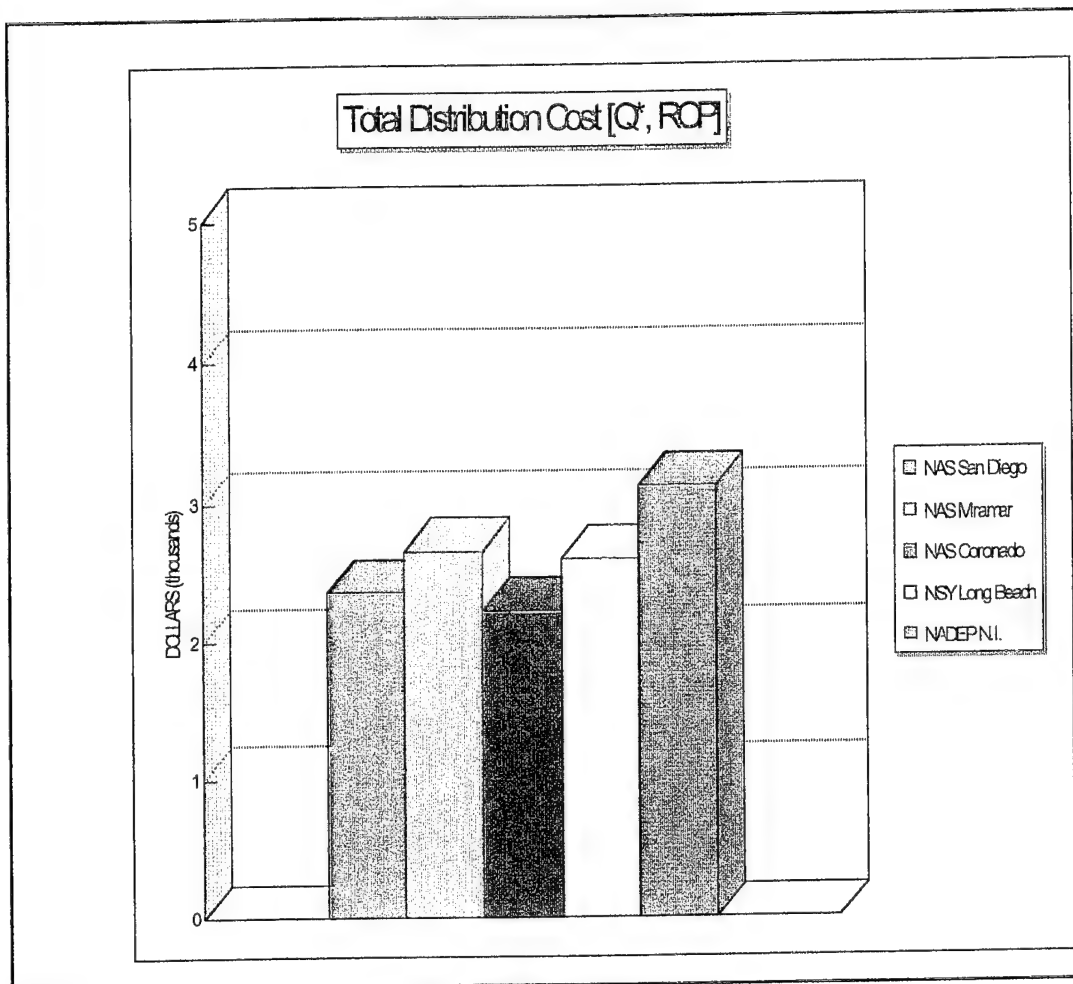
ROP: 8.31

$TDC(Q, ROP) = (mD/Q \times S) + (Q/2 \times HC) + (SS \times HC) + (SC \times mD/Q \times rddlt \times E[SS/rddlt])$

$TDC(Q, ROP) = 180.48 + 180.48 + 2108.51 + 550$

**TDC = \$3,019.47**

**Figure 18** NADEP North Island TDC Summary

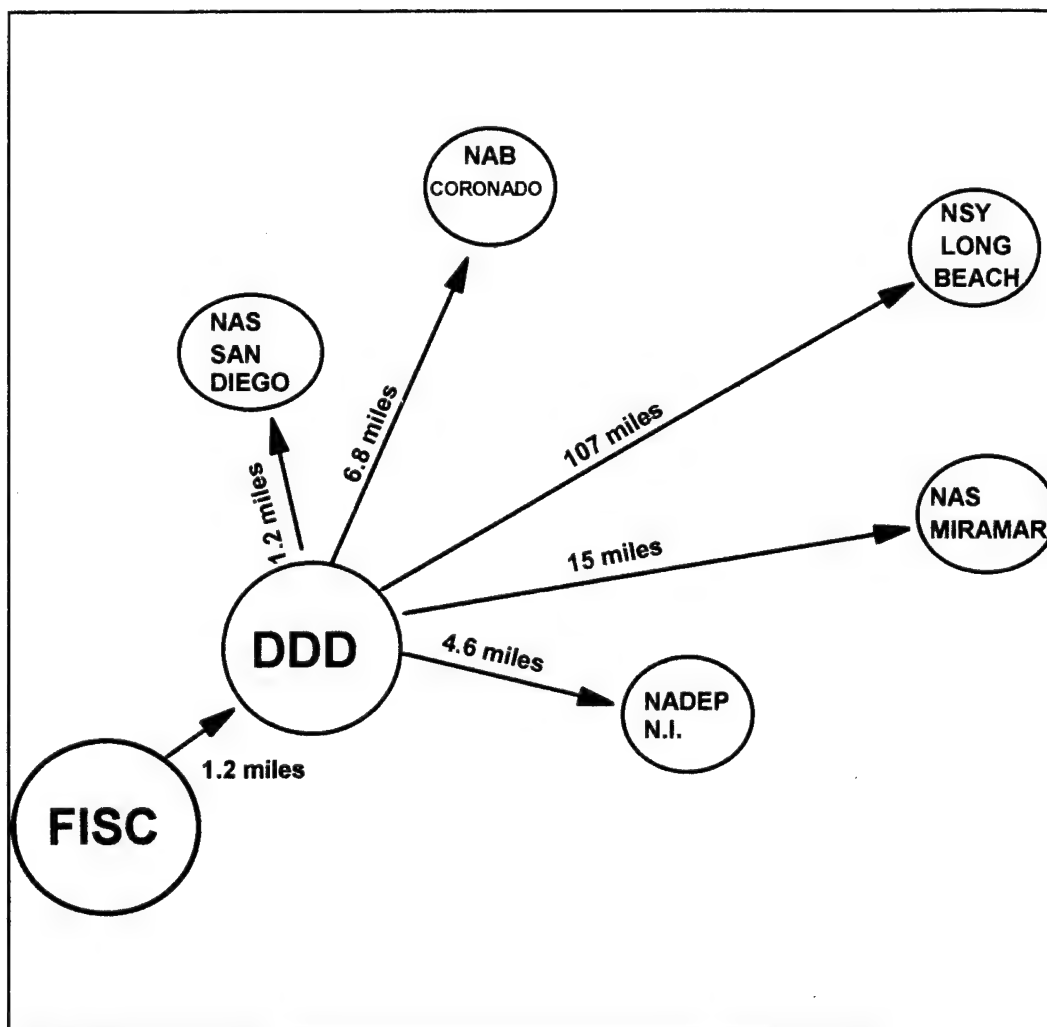


**Figure 19** End User TDC Comparison

#### **D. CONSOLIDATED INVENTORY MANAGEMENT SCENARIO**

This case examines total distribution costs for the flux sensor which is managed under the regional consolidation concept. This scenario assumes the physical location of the item is centrally located at the FISC warehouses in San Diego (see Figure 20). The demand data for the five activities is combined to formulate the overall demand for the consolidated activity. The same formulas utilized to determine the set up, holding, and stock out

costs in the individual scenario are used to calculate the costs in the consolidated model. The total distribution cost to manage the flux sensor under the consolidated inventory model is then predicted. Figure 21 presents the data, and highlights the total distribution cost for the consolidated alternative. Figure 22 graphically compares the total distribution costs for the two alternatives.



**Figure 20** FISC Consolidated Inventory Management

# FISC CONSOLIDATED INVENTORY OPTION

## Demand History:

	year 1	year 2	year 3
JANUARY	14	17	12
FEBRUARY	16	15	15
MARCH	16	13	11
APRIL	15	15	20
MAY	20	15	14
JUNE	18	14	10
JULY	10	15	7
AUGUST	14	13	10
SEPTEMBER	13	16	15
OCTOBER	13	12	11
NOVEMBER	16	11	11
DECEMBER	<u>12</u>	<u>11</u>	<u>11</u>
Yearly Demand:	177	167	147
Avg Yrly Demand:	163.67 (mD)		26786.78 (m2D)
Demand Variance:	233.33 (r2D)		
Standard Deviation:	15.28 (rD)		

## Set Up Costs (S):

Transportation Costs (TC):	Distance	Rate		Cwt	Cost
DDD to FISC	1.2	0.86	x	2.5	2.15
FISC to NAS MIRAMAR	15	0.86	x	2.5	2.15
FISC to NAS SAN DIEGO	1.2	0.86	x	2.5	2.15
FISC to NSY LONG BEACH	107	1.18	x	2.5	2.95
FISC to NAB CORONADO	6.8	0.86	x	2.5	2.15
FISC to NADEP NORTH ISALND	4.6	0.86	x	2.5	<u>2.15</u>
					13.7
Order Costs:					<u>3</u>
				S=	16.7

## Holding Costs (HC):

Warehousing (FC):	1.00%	15
Time Value of Money:	10.00%	150
Obsolescence:	10.00%	150
Theft, Shrinkage:	2.00%	<u>30</u>
HC=		345

Stock Out Cost (SC): 10.00% 150

EOQ: 3.98

rddlt: 16.79

SS/rddlt=  $E - 1[Q \times (1 - SL)] / rddlt =$  0.02  
 $E - 1[.02] =$  1.66

SS/rddlt: 1.66

SS: 27.87

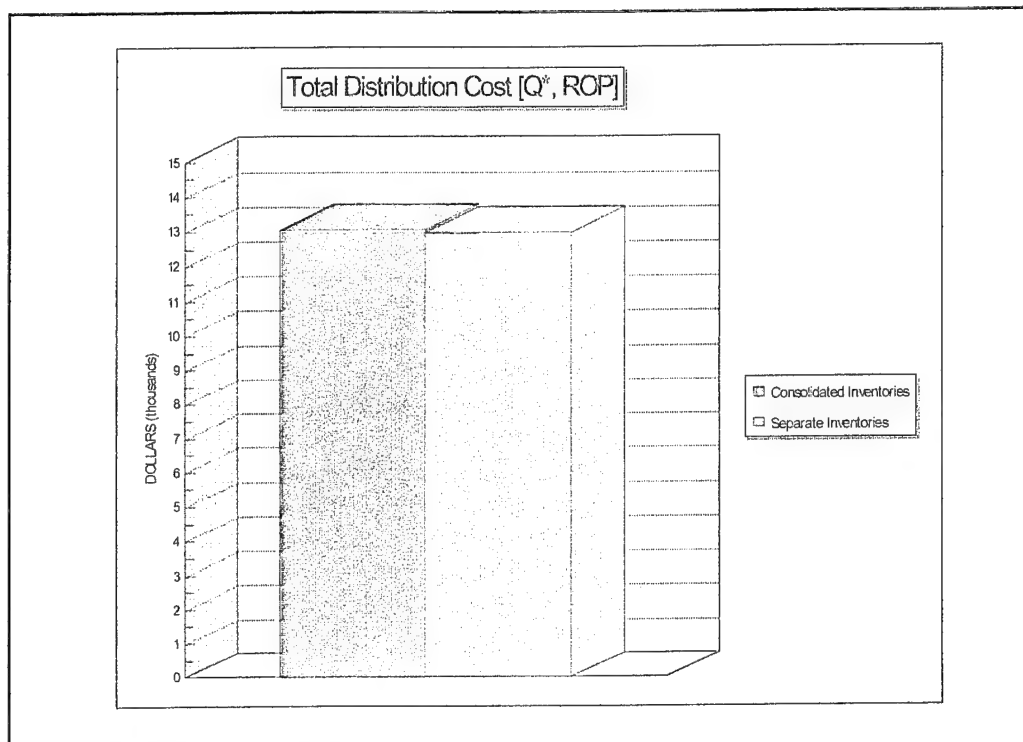
ROP: 37.69

$TDC(Q, ROP) = (mD/Q \times S) + (Q/2 \times HC) + (SS \times HC) + (SC \times mD/Q \times rddlt \times E[SS/rddlt])$

TDC(Q, ROP) = 686.65 + 686.65 + 9615.01 + 2455

TDC = \$13,443.31

**Figure 21** Consolidated Inventory TDC Summary



**Figure 22** TDC Comparison

#### **E. SUMMARY**

In this chapter we applied our total cost model as developed in Chapter III. The primary focus was to determine which of the two inventory management alternatives provided the lowest total distribution cost. Our model formulated the total distribution cost of each scenario by applying the selected system parameters. Our key parameters included: item demand, holding cost rate, set up cost, procurement lead time, and unit cost. These parameters served as the basis for comparing the TDCs, which were a function of the reorder quantity and reorder point.

In assessing the efficiency of both end user inventory management to consolidated inventory management, this case has indicated that consolidation does not always equate to a reduction of total distribution cost.

## V. DATA ANALYSIS

### A. INTRODUCTION

As previously defined in Chapter III, the concept of military logistics is the entire process of moving materials from the manufacturer into, through and out of an intermediate storage area, and on to the end user. We also stated that military logistics consists of two distinct processes (materials management and physical distribution) and that we will focus our attention primarily on the physical distribution process.

The physical distribution system consists of the following major activities: transportation, inventory management, requisition processing and warehousing. In Chapter IV, we formulated a total distribution cost model to capture the relevant costs associated with these various activities. Chapter IV also illustrated that the total distribution costs attributed to each model were virtually identical. This chapter examines in detail the underlying costs that comprise the total distribution model to determine whether or not any important differences exist.

In conducting our analysis, we examined the following systems parameters: economic order quantity (EOQ), reorder point (ROP), required safety stock level, holding cost of safety stock, average inventory holding cost (as a function of the optimal order quantity  $[Q^*]$  and ROP), various transportation costs (to include average transportation cost  $[Q^*, ROP]$ , and transportation cost per item. Our analysis reveals notable differences in the following parameters: economic order quantity, reorder point, required amount of safety stock, average inventory holding costs, and transportation costs. Consequently, the remainder of this chapter is devoted to further examining these parameters and illustrating, graphically, our significant findings.

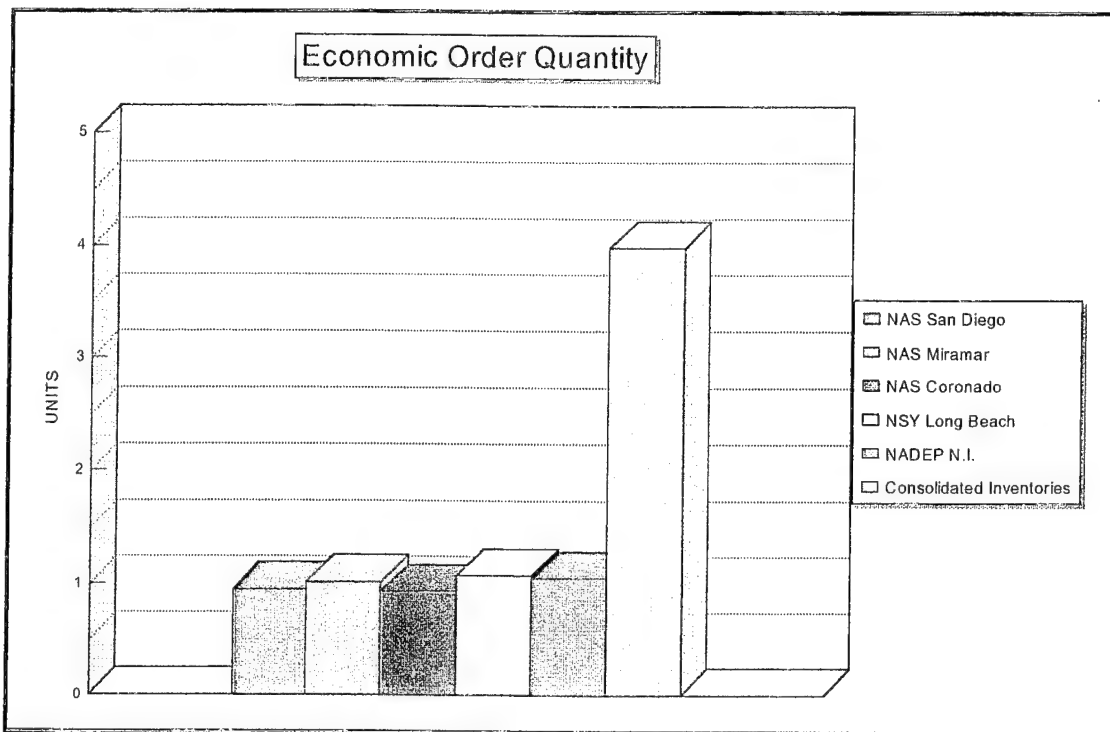
This chapter is broken into two major sections. The first section highlights and discusses a few of the most important cost differences between the two inventory models. In this section,

we introduce each specific parameter, briefly discuss its relevance to the model, and highlight the key implications of each graph. The second section introduces an alternate system parameter (demand variance) upon which to base our comparison. Here, we conduct a trend analysis in which we vary the yearly demand of the repair part keeping all other parameters constant. The purpose of this analysis is to validate an alternate system parameter upon which to base our selection decision should the total cost criterion prove to be inconclusive.

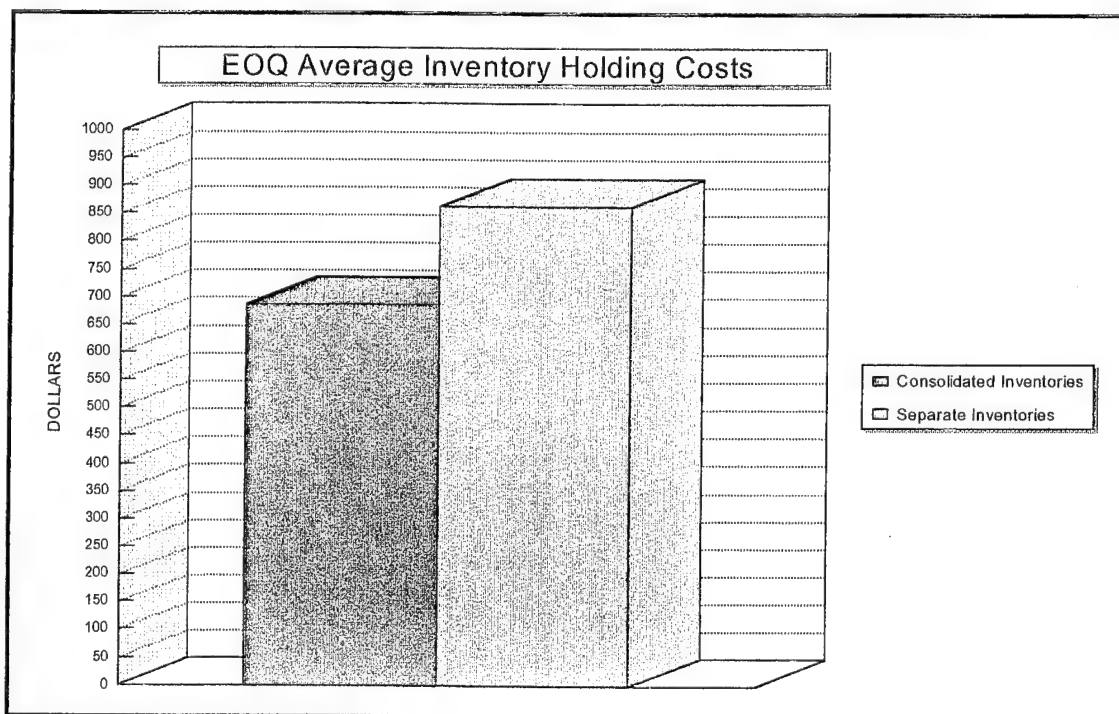
## **B. SYSTEM PARAMETERS**

### **1. Economic Order Quantity (EOQ)**

The main purpose of this analysis is to find an optimal value for the order quantity while minimizing total costs. Figure 23 shows the different EOQs for the two models. Under the consolidated model, when the inventory level of the flux sensor drops to the ROP, an order of four is placed. This results in a three dollar reorder cost. Conversely, under the separate inventory model, the EOQ is one flux sensor per activity resulting in cumulative ordering cost that is five times greater than the consolidated model cost. This equates to approximately fifteen dollars. The lower EOQ in the consolidated model also leads to lower average inventory holding costs with respect to  $Q^*$ . Figure 24 translates the unit efficiencies depicted in Figure 23 to dollars. The lower EOQ for the consolidated model equates to a \$178.11 savings. Hence we conclude that since the consolidated method has the lower EOQ, it provides the greater efficiency.



**Figure 23** Comparison of EOQ



**Figure 24** Comparison of Average Inventory Holding Costs

## 2. Reorder Point (ROP) and Safety Stock (SS)

This analysis focuses on the reorder point and safety stock. ROP is the point where inventory is depleted to a level which is equal to or less than a specified quantity. At this point, an order for  $Q^*$  would be placed. Safety stock is a back-up supply of product which is held for use in an emergency. As shown in Figure 25, the ROP for the consolidated inventory option is 37 flux sensors while the cumulative ROP for the separate inventory model is 35. The higher ROP in the consolidated model, in turn, leads to greater SS as shown in Figure 26. As previously stated, holding inventory is costly. Figure 27 depicts the additional cost associated with the consolidated model's higher ROP and SS.

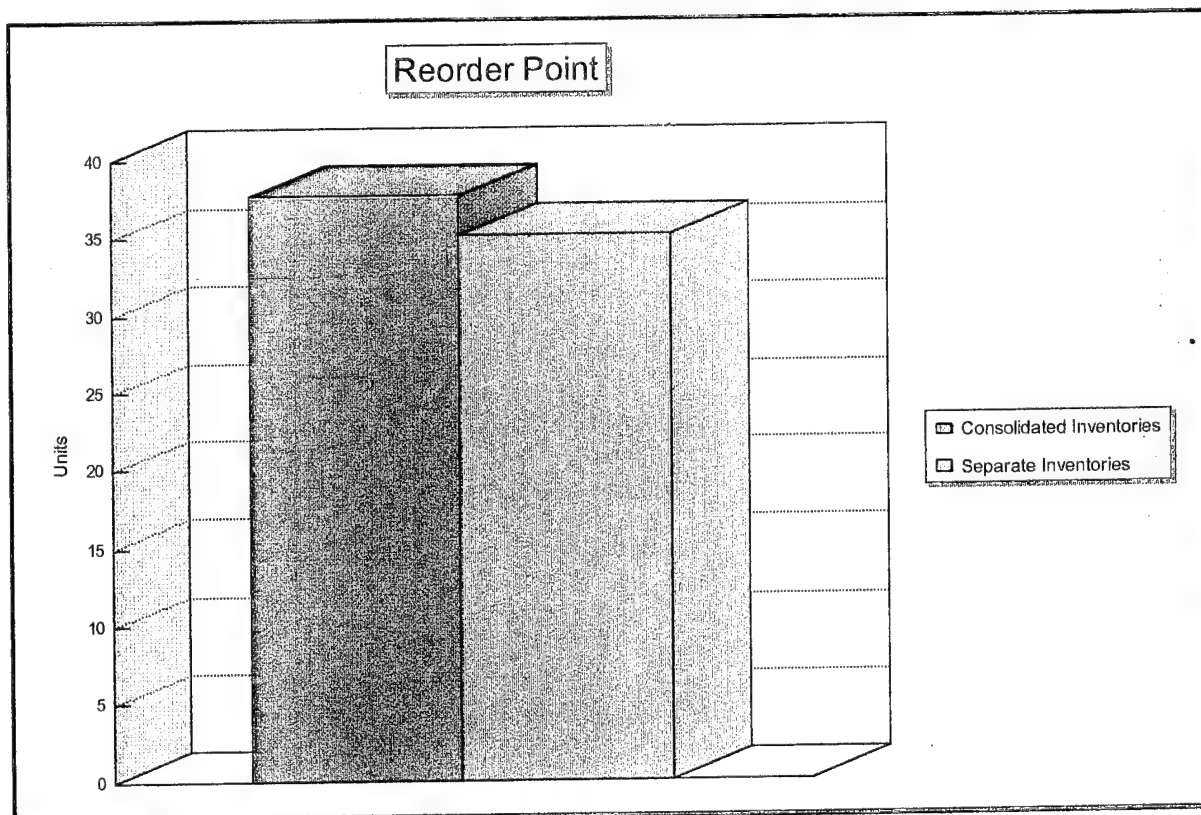
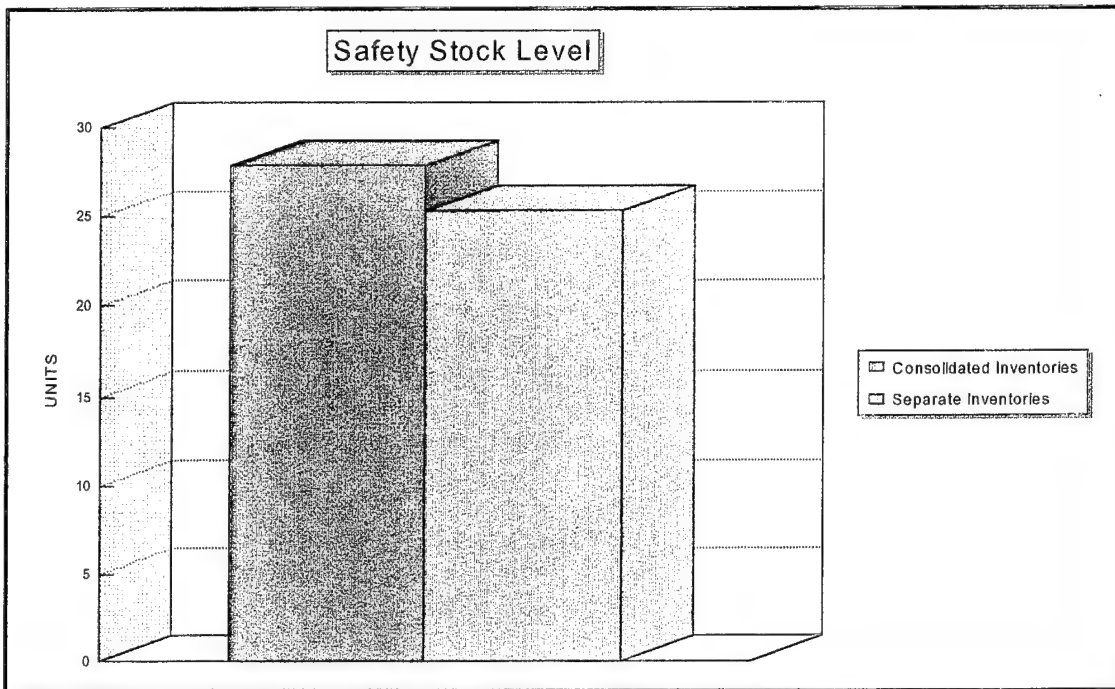
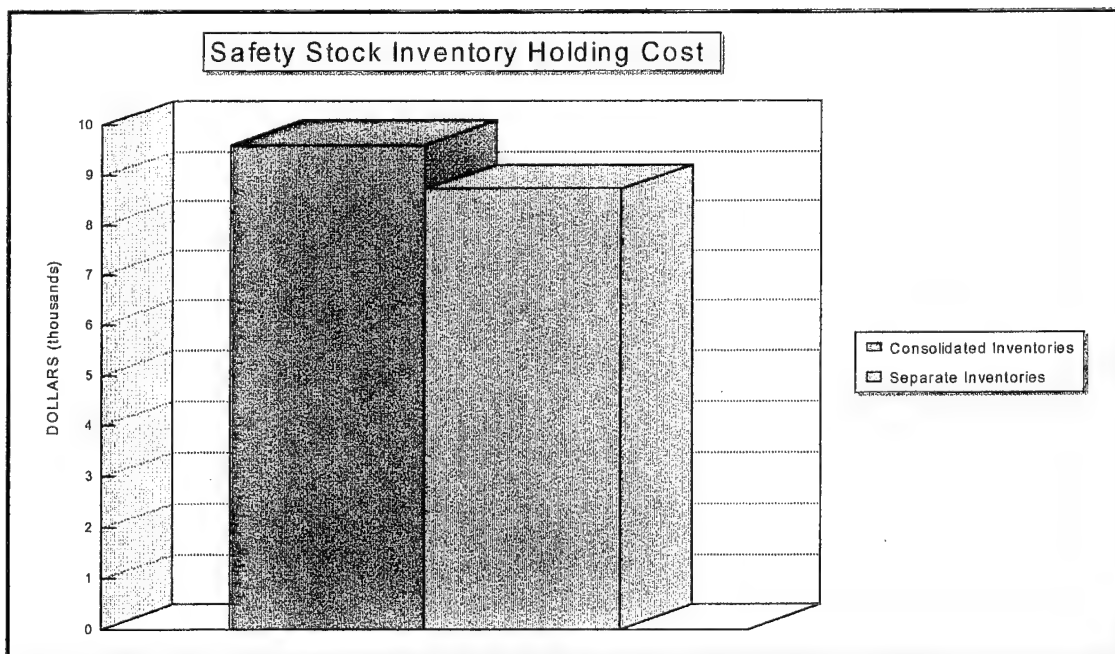


Figure 25 Comparison of ROP



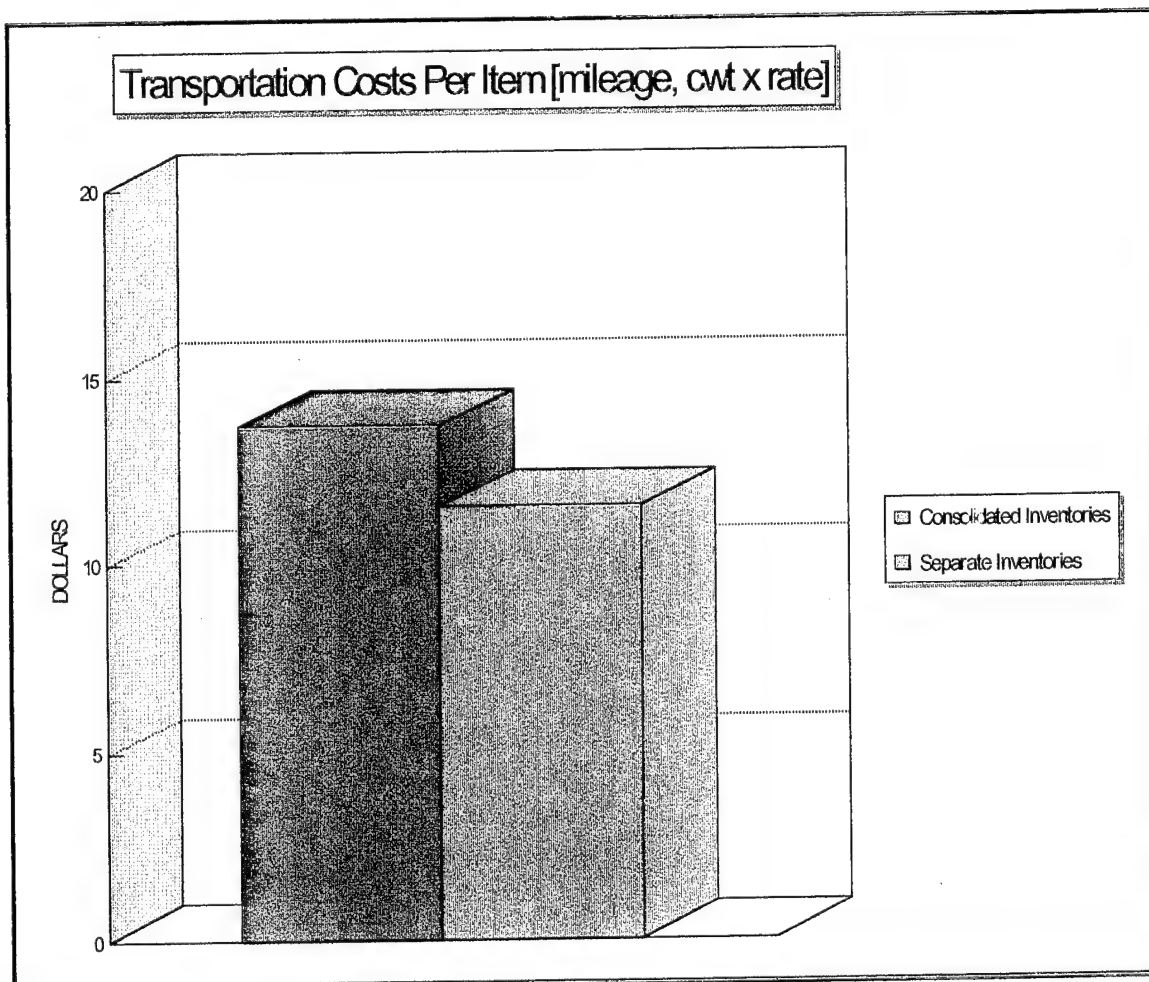
**Figure 26** Comparison of Safety Stock Level



**Figure 27** Comparison of Safety Stock Holding Cost

### 3. Transportation Cost

As Figure 28 shows, transportation cost for the flux sensor is higher under the consolidated inventory model. This additional cost is also evident by comparing Figure 13 with Figure 20 (in Chapter IV). Under the consolidated inventory model, an additional distribution node is present. This, in turn, leads to an increase in transportation cost. Under this scenario, the additional transportation cost is the primary reason that the total distribution cost is greater under the consolidated model.



**Figure 28** Comparison of Transportation Costs

#### 4. Total Distribution Cost

The previous graphs depicted comparisons of the critical system parameters. As our analysis has shown, there are cost advantages inherent in both inventory models. It also indicates specific savings in one area are often offset by costs in another. As Figure 29 shows, the effect of the trade-offs between the two inventory models resulted in a negligible difference in the total distribution costs. Therefore, we surmise that we can not base our selection decision solely on a total cost basis and must develop alternative selection criteria.

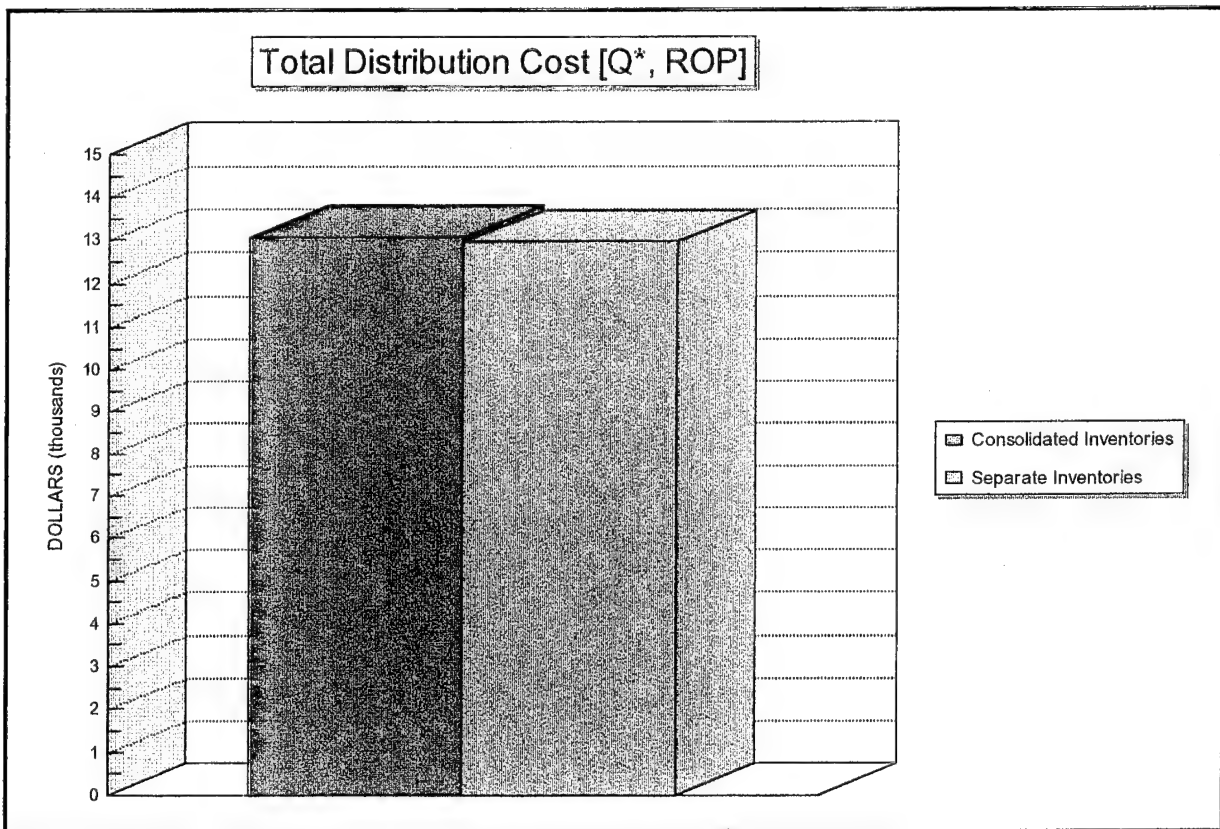


Figure 29 Comparison of Total Distribution Costs

### C. DEMAND VARIANCE: AN ALTERNATE SELECTION CRITERION

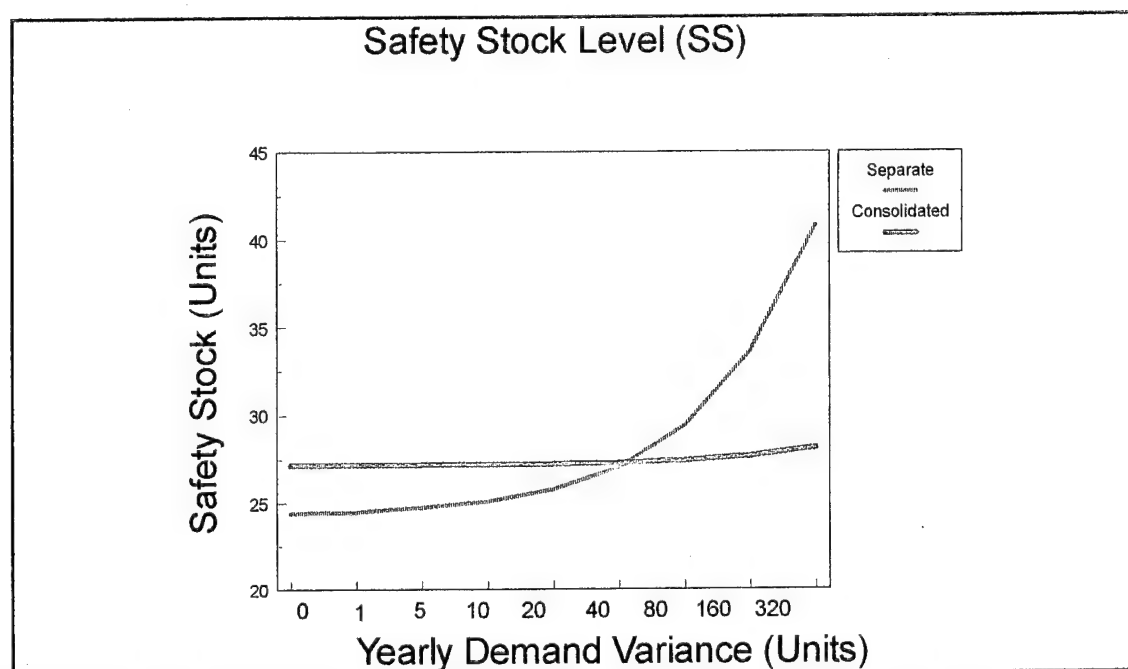
As we have learned in the previous section, maintaining separate end user inventories initially affords us the lowest total distribution cost. We have also discovered that the total cost difference between the two inventory models is not sufficient to base our entire selection decision upon that single discriminator. We must further analyze the cost data to ascertain whether there are certain cost trends present that would favor the selection of consolidated inventories as our model of choice.

First, we must keep in mind the primary reason for maintaining inventories. Inventories exist mainly to ensure that our maintenance activity can be performed with minimal delays. At times, this task can become virtually impossible, particularly when it is difficult to predict customer demand. In the military, the amount of repair parts ordered is largely a function of a unit's operating target (OPTAR) and operating tempo (OPTEMPO). During times of uncertainty, it is virtually impossible to maintain a steady rate of item demand. Therefore, it is during time of uncertainty when we experience large fluctuations or variances in customer demand.

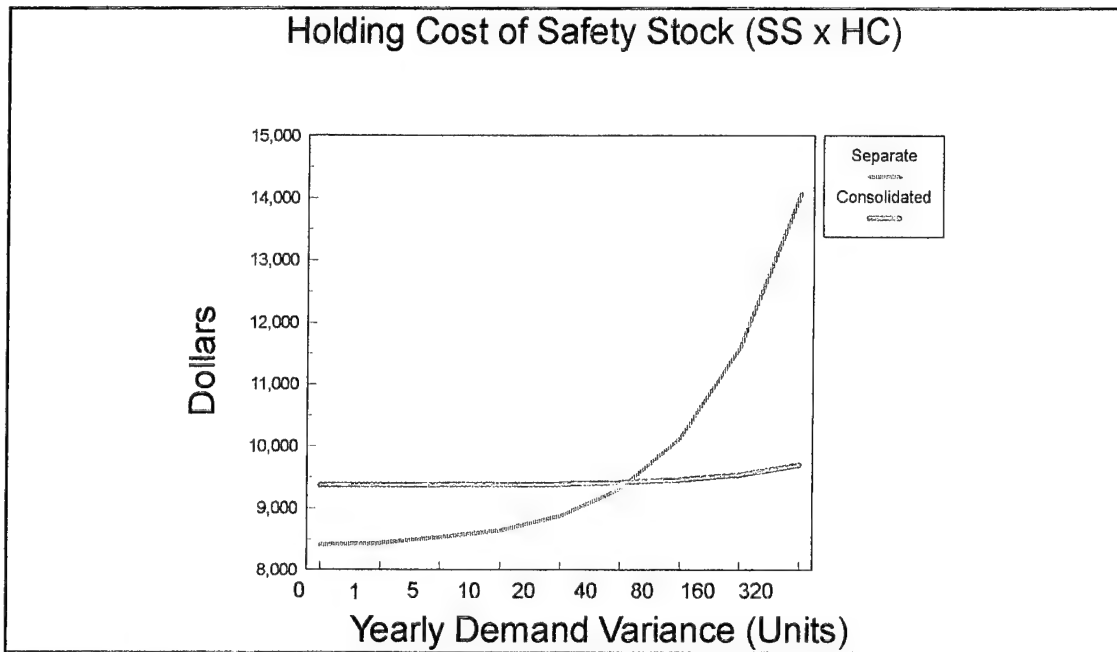
Second, we must also remember that it takes time to physically move an item from the storage point to the consumer. Additionally, it is possible that substantial amounts of inventory are tied up somewhere in the pipeline under both systems. This affects the amount of lead time required to process a particular order. As demand begins to vary greatly, the forecasts used to determine inventory levels become less reliable. Consequently, the amount of lead time required to restock tends to become longer. Therefore, demand variance increases the required lead time, and directly increases the unit's exposure to risk.

Since the total distribution cost criterion has not measured significant differences between the two models, we have decided

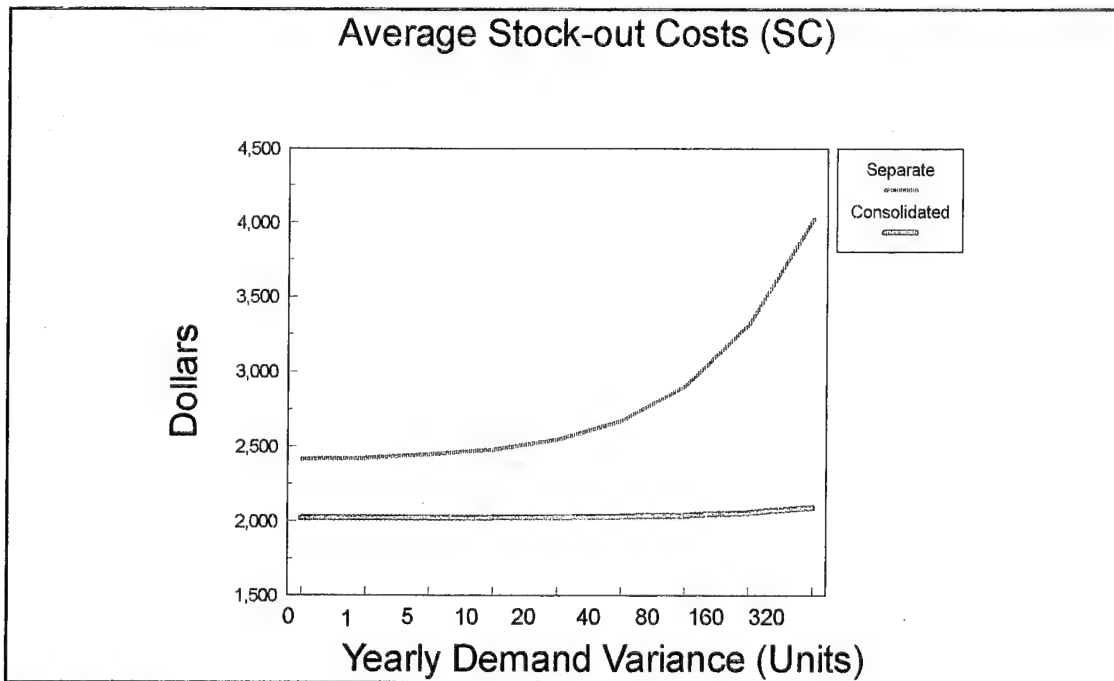
to examine an alternate discriminator. We decided to use demand variance as our secondary criterion for the following reasons: First, it is realistic given the present state of political affairs; second, demand variance directly impacts upon the amount of lead time required to process an order; and finally we contend that if ignored, it can have a devastating impact upon unit readiness. Figures 30 through 33 highlight the findings of our second inventory model comparison. Figure 30 shows the impact of demand variance upon safety stock. Figure 31 translates this information from units to dollars. Figure 32 conveys the impact of demand variance on average stock out costs. Figure 33 shows the significant impact of demand variance upon total distribution cost. As these figures indicate, when demand varies, the effect under the consolidated model is negligible while under the separate option there is a disproportionate increase in all measured costs. Therefore, we conclude that as the demand variance increases the consolidated inventory model would be more attractive.



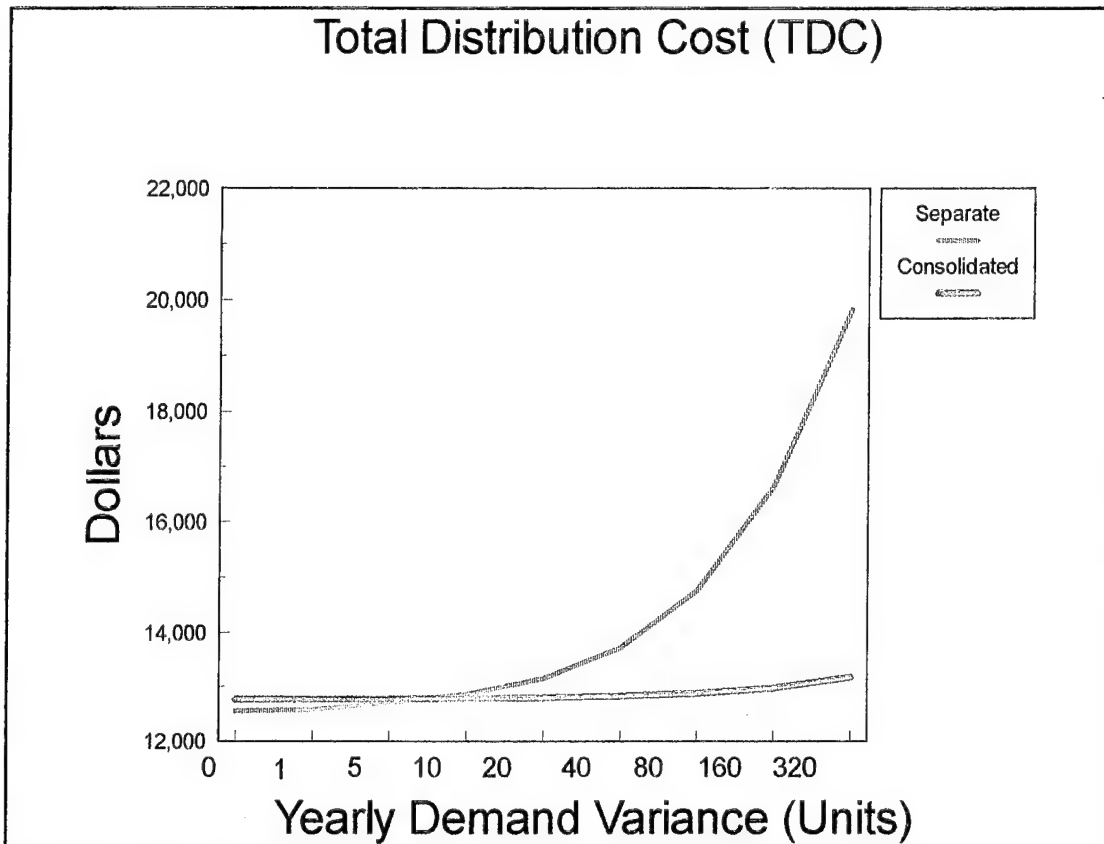
**Figure 30** Effects of Demand Variance on Safety Stock



**Figure 31** Effects of Demand Variance on SS Holding Cost



**Figure 32** Effects of Demand Variance on Avg Stock-out Cost



**Figure 33** Effects of Demand Variance on Total Distribution Cost



## VI. CONCLUSION AND RECOMMENDATIONS

### A. CONCLUSION

In recent years, the Department of Navy has increasingly focused its attention on the cost of maintaining inventories. Therefore, much emphasis has been placed upon sound inventory management practices. As a result of this increased focus on logistics management, effective physical distribution procedures are being integrated into every facet of our warfighting doctrine.

In an attempt to streamline logistics support, the Department of Defense has mandated DMRD 902, which eliminated the intermediate level of inventories. Concerned with the prospect of unnecessarily degrading unit readiness through the elimination of this level of inventory, NAVSUP sponsored a pilot program to determine the effectiveness of consolidating end user inventory at the FISC level. Our study compared these two alternative inventory strategies: end users maintaining separate inventories and end users' inventories being consolidated at the FISC level.

To determine which inventory model would be most beneficial to the Department of Navy, we conducted an analysis to evaluate the difference in costs between pre and post consolidation inventory methods. In our scenario, we initially selected total distribution cost to use as our primary model discriminator. As our analysis has shown, both TDCs were nearly identical and could not be used as the primary discriminator. We therefore considered other evaluation criteria and selected demand variance as an alternate method of comparison upon which to base our decision.

Figures 30 through 33 graphically depict the major findings of this study. As these figures indicate, demand variance significantly increased TDC under the separate inventory model, but had a negligible effect upon the consolidated model. In fact, this observation held true under all examined parameters. Even though we have shown under this scenario that TDC is

slightly less under the end user model, we contend that the minimal additional cost in the consolidated model is worth the investment. The future holds great uncertainty for the military and Navy. Inventory consolidation can reap disproportional advantages of lower physical distribution costs during times of uncertainty.

Our findings support the conclusion that total distribution costs are minimized when inventories are consolidated at the FISC level. However, these findings cannot be universally applied. In other words, our final conclusion may not be applicable when applied to different scenarios. We merely examined the role of total distribution costs and demand variance upon two alternative physical distribution models.

## **B. RECOMMENDATIONS**

We recommend the consolidation of end user inventory at the FISC level. The inventory consolidation affords the same customer service level as separate end user inventories, at a significantly lower cost when combined with uncertain demand. We contend that the uncertain demand which is prevalent today will continue in years to come.

We further recommend reducing unnecessary inventory requirements and infrastructure. Specifically, additional end user inventory consolidation should be studied as an area of potential savings. For example, the DOD should consider consolidation of all inventories at the DLA level.

Lastly, we recommend examining the possibility of establishing direct access of supplier parts to end users. By placing suppliers near DOD maintenance facilities, this would eliminate the need to store supplies in the DOD logistics system. The use of Just-in-Time inventory practices could be used to further reduce logistics infrastructure and operating expenses.

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